Interaksi Molekuler Amonium Hidroksida

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Abstrak. Amonium hidroksida adalah larutan amonia didalam air dengan rumus NH_4OH . Amonium hidroksida merupakan senyawa yang tidak berwarna dan memiliki bau yang sangat tajam. Penelitian ini bertujuan untuk menganalisis interaksi molekuler dan kinetik dari amonium hidroksida. Metode yang digunakan adalah pemodelan dengan *ChemOffice 15.0*. Untuk mengetahui konduktivitas, mobilitas, viskositas, kecepatan hanyut dilakukan dengan menggunakan rumus dan data dari hasil review jurnal penelitian yang berkaitan dengan amonium hidroksida seperti tahapan pada *fishbond*. Amonium hidroksida mempunyai termokimia dalam fase likuit dengan $\Delta H, \Delta G, S^\circ$, dan C_p yang masing-masing mempunyai nilai -361.2 kJ/mol, -254.0 kJ/mol, 165.6 J/molK dan 154.9 J/molK. Mobilitas ion NH_4 dan OH^- adalah 3.5 dan 1. Amonium hidroksida juga mempunyai energi kinetik yang hasilnya dapat diketahui dengan menggunakan *chemoffice 15.0* yaitu sebesar 0,43.

Kata Kunci: Amonium hidroksida, pemodelan, interaksi molekuler

1. Pendahuluan

Amonium hidroksida merupakan golongan amonia yang biasa digunakan sebagai pendingin, pupuk, bahan pembersih dan pemutih, dan pada bahan keperluan rumah tangga lainnya. Amonium Hidroksida merupakan larutan yang berwujud cair, tidak berwarna, bau yang kuat, sangat larut dalam air dan mempunyai pH basa yaitu 13,6 pada 32°F, pH 11,7 pada 20°C, pH 13,8 pada larutan 29%⁽⁹³⁾. Amonium Hidroksida atau yang dikenal dengan rumus NH_4OH mempunyai berat molekul 35,04 g/mol dengan titik didih 37,7 °C (99,9 °F; 310,8 K) (25% w/w) dan titik lebur -57,5 °C (-71,5 °F; 215,7 K) (25% w/w) -91.5 °C (35% w/w)⁽²⁸⁾.

Amonia di dalam larutan berair akan terdeprotonasi sebagian dari air sehingga menghasilkan amonium dan hidroksida⁽⁹³⁾ seperti reaksi kesetimbangan berikut:

Larutan amonia 1M hanya 1,42% dari amonia yang dapat diubah menjadi amonium, ini setara dengan pH 11,63. Konstanta ionisasi biasanya adalah

$$K_b = [\text{NH}_4^+][\text{OH}^-]/[\text{NH}_3] = 1.8 \times 10^{-5}$$

Amonium Hidroksida juga mempunyai konduktivitas dimana jika konduktivitas NH_4OH meningkat dengan meningkatnya konsentari. Besarnya konduktivitas ditentukan oleh konsentrasi elektrolit. Pembawa muatan dapat berupa elektron seperti logam atau dapat juga digunakan ion positif dan ion negatif seperti dalam larutan elektrolit dan lelehan garam. Arus listrik terjadi didalam suatu larutan karena adanya ion yang bergerak.

Termokimia larutan NH_4OH dibagi menjadi dua, yaitu entropi molar standar dan entalpi molar standar. Termokimia amonium hidroksida terdiri dari $\Delta H, \Delta G, S^\circ$, dan C_p yang masing-masing mempunyai nilai -361.2 kJ/mol, -254.0 kJ/mol, 165.6 J/molK dan 154.9 J/molK.

Amonium hidroksida dapat beresiko terjadinya ledakan atau terbentuk gas toksik terhadap bahan Oksidator, Air Raksa, Oksigen, senyawa silver, Nitrogen Trichloride, Hidrogen Peroksida, Silver, Antimoni Hydrat, Halogen, Asam Kalsium, Klorin, Klorit, garam auric perchlorates, Natrium Hipoklorit, senyawa merkuri, dan Halogen Oxides⁽⁹⁴⁻¹⁰⁸⁾.

Bukan hanya itu, amonium hidroksida juga dapat beresiko isnisi dan pembentukan gas atau uap yang tidak menyala dengan borana, boron, Oksida Fosfor, Asam Nitrat, Senyawa Silikon, Chromium(IV) Oxide dan chromyl chloride.

Amonium hidroksida juga dapat bereaksi eksotermik dengan Acetaldehyde, Acrolein, Barium, senyawa boron, Bromida, senyawa halogen, Hydrogen Bromida, Silane, Gas Hidrogen Klorida, Dimethylsulfate, Nitrogen Oxides, Flourin, Hidrogen flourida, dan Carbon dioxide⁽⁹³⁾.

Penelitian ini bertujuan untuk mengetahui interaksi molekuler dari amonium hidroksida dengan menggunakan aplikasi *chemoffice 15.0* serta untuk mengetahui sifat fisika dan sifat kimianya begitu juga dengan bahaya bagi manusia jika terhirup atau terkena amonium hidroksida

2. Metode

Metode yang digunakan yaitu penggambaran molekul dengan aplikasi *ChemOffice 15.0*. Untuk analisis lanjut mengenai NH_4OH dilakukan beberapa tahapan seperti yang tampak pada *fishbond* dibawah ini.

Penelitian dilakukan beberapa tahap, yaitu (1) Analisis 2D molekul NH_4OH secara dua dimensi dengan menggunakan *ChemDraw 2D*, (2) Analisis molekul NH_4OH secara 3D menggunakan *Chem3D*

Pada bagian *Chem3D*, struktur NH_4OH akan berubah menjadi bentuk 3 dimensi dan kemudian dilakukan beberapa analisis, seperti :

1. Menghitung MM2 dari masing-masing molekul yang terdiri atas MM2 minimization, MM2 dynamics dan MM2 properties. Caranya dengan pilih pada bagian *calculation*, pilih MM2 minimization kemudian pilih *minimize energy* lalu run. Dengan cara yang sama untuk menentukan *molecular dynamics dan compute properties*.
2. Analisis surface molekul, diantaranya *Surface Solvent Accesible* dengan tipe solid, wire mesh dan tranculent. Kemudian *Surface Connolly Molecular* dengan tipe solid, wire mesh dan tranculent.
3. Menghitung MOPAC dari masing-masing molekul yang terdiri dari MOPAC minimization dan MOPAC properties. Caranya dengan pilih MOPAC, kemudian pilih MOPAC minization kemudian pilih run. Dengan cara yang sama untuk menentukan MOPAC properties.
4. Analisis jarak antara masing-masing atom tiap-tiap, molekul dengan pilih bagian *structure*, kemudian pilih *measurement*.

3. Pembahasan

a) Sifat Amonium Hidroksida (NH_4OH)

Gambar 1. Ammonium Hydroxide⁽⁹⁷⁾

Larutan amonia di dalam air banyak dikenal juga sebagai amonia berair, akua amonia, amonia encer, larutan amoniakal, atau secara sederhana disebut dengan amonia dan seraca umum dikenal dengan amonium hidroksida. Rumus senyawa dari amonia adalah $\text{NH}_3(\text{aq})$. Nama dari amonium hidroksida memperlihatkan suatu alkali dengan komposisi $[\text{NH}_4^+][\text{OH}^-]$, faktanya NH_4OH sangat sulit untuk dipisahkan, karena ion dari NH_4OH tidak

terdiri dari bagian yang substansial dari seluruh amonia kecuali di dalam larutan yang sangat encer⁽¹⁰⁹⁻¹¹⁶⁾.

Amonium hidroksida mempunyai massa molar sebesar 35.04 g/mol dengan titik didih 37,7 °C (99,9 °F; 310,8 K) (25% w/w) dan titik lebur -57,5 °C (-71,5 °F; 215,7 K) (25% w/w) -91.5 °C (35% w/w). Amonium hidroksida juga memiliki kerapatan (densitas) 0.91 g/cm³ (25 % w/w) dan 0.88 g/cm³ (35 % w/w) dimana densitas NH₄OH merupakan massa per unit volume zat pada suhu tertentu dan tidak hanya ditentukan oleh ukuran dan bobot molekul zat tetapi juga ditentukan oleh gaya atraksiantar molekul.

Amonium hidroksida bersifat tidak berwarna, mudah menguap dan memiliki bau yang sangat tajam sehingga NH₄OH dapat bersifat racun karena dapat melepaskan gas amonia ke udara^(62, 117-125).

b) Bentuk Molekul

Amonium Hidroksida (NH₄OH) terdiri dari atom N, H dan O. Nitrogen termasuk golongan VA yang mempunyai 5 elektron di kulit terluarnya dan Hidrogen merupan golongan IA yang mempunyai 1 elektron di kulit terluarnya, serta Oksigen dari golongan VIA yang mempunyai 6 elektron di kulit terluarnya. Sehingga bentuk molekul NH₄OH adalah tetrahedral^(18, 126-129).

Gambar 2. Amonium Hidroksida 3D (N .L. Allinger, J. Comput. Chem. 1993, 14, 755-68)

(a)

(d)

(b)

(e)

(c)

(f)

Gambar 3. Analisis 3D Surface NH₄OH. (a) Solvent Accessible Molekul NH₄OH, (b) dan (c) Solvent Accessible Molekul NH₄OH Mode Wire Mesh dan Translucent. (d) Connolly Molecular NH₄OH, (e) dan (f) Connolly Molecular NH₄OH Mode Wire Mesh dan Translucent (N .L. Allinger, J. Comput. Chem. 1993, 14, 755-68)

Output MM2 Minimization, Dynamics, dan Properties

-----MM2 Minimization-----

Adding lone pairs to N N(1)

Adding lone pairs to O O(2)

Warning : Some parameters are guessed (Quality = 1).

Iteration 70 : Minimization terminated normally because the gradient norm is less than the minimum gradient norm

Stretch : 0.0016

Bend : 0.0030

Stretch-Bend : -0.0000

Torsion : 0.0000

Non-1,4 VDW : -0.2680

1,4 VDW : -0.0539

Total : -0.3173

Warning : Some parameters are guessed (Quality = 1).

Iteration 1 : Minimization terminated normally because the gradient norm is less than the minimum gradient norm

Stretch : 0.0013

Bend : 0.0033

Stretch-Bend : -0.0000

Torsion : 0.0000

Non-1,4 VDW : -0.2680

1,4 VDW : -0.0540

Total : -0.3174

-----MM2 Dynamics-----

Warning: Some parameters are guessed (Quality = 1).

Time	Total Energy	Potential Energy	Temperature
0.010	-0.259 ± 0.041	-0.308 ± 0.013	1.63 ± 0.99
0.020	-0.165 ± 0.021	-0.280 ± 0.022	3.86 ± 1.17
0.030	-0.111 ± 0.012	-0.270 ± 0.016	5.32 ± 0.48
0.040	-0.071 ± 0.015	-0.258 ± 0.020	6.28 ± 0.75
0.050	-0.013 ± 0.013	-0.244 ± 0.022	7.75 ± 0.73
0.060	0.069 ± 0.017	-0.219 ± 0.030	9.67 ± 0.45
0.070	0.125 ± 0.017	-0.211 ± 0.044	11.29 ± 1.05
0.080	0.190 ± 0.030	-0.188 ± 0.049	12.67 ± 1.59

0.090	0.255 ± 0.019	-0.151 ± 0.048	13.62 ± 1.55
0.100	0.315 ± 0.025	-0.136 ± 0.050	15.13 ± 1.72
0.110	0.389 ± 0.029	-0.108 ± 0.044	16.67 ± 1.50
0.120	0.455 ± 0.023	-0.100 ± 0.055	18.61 ± 1.52
0.130	0.517 ± 0.027	-0.087 ± 0.041	20.28 ± 1.54
0.140	0.585 ± 0.021	-0.061 ± 0.034	21.67 ± 1.58
0.150	0.657 ± 0.015	-0.040 ± 0.044	23.40 ± 1.75
0.160	0.718 ± 0.015	-0.015 ± 0.059	24.60 ± 1.86
0.170	0.766 ± 0.020	-0.020 ± 0.050	26.35 ± 1.87
0.180	0.837 ± 0.020	0.005 ± 0.052	27.89 ± 2.18
0.190	0.901 ± 0.017	0.016 ± 0.061	29.70 ± 2.15
0.200	0.955 ± 0.020	0.012 ± 0.088	31.64 ± 2.86

Translational Kinetic Energy: 0.0000 Rotational Kinetic Energy: 0.4389

-----MM2 Properties-----

Warning : Some parameters are guessed (Quality = 1).
 Stretch : 0.7813
 Bend : 1.9693
 Stretch-Bend : 0.0278
 Torsion : 0.0000
 Non-1,4 VDW : 0.0000
 1,4 VDW : 0.1546
 Total : 2.9330

The steric energy for frame 1 : 2.933 kcal/mole

Extended Hucle Charge

Deleting lone pairs

N -0.100	N(1)
O -0.268	O(2)
H 0.089	H(3)
H 0.086	H(4)
H 0.193	H(7)
H 0.000	H(5)
H -0.000	H(6)

The RMS Deviation from the plane is 6.206Å.

Output MOPAC Minimization, dan Properties

-----MOPAC Minimization-----

Heat of Formation : -28.09053 kcal/mole
 Gradient Norm : 0.04688

-----MOPAC Properties-----

Heat of Formation : -28.09053 kcal/mole
 Gradient Norm : 0.00000
 Dipole : -0.451 0.291 -0.150
 Magnitude : 0.557 Debye

Charges

N(1) -0.29622	N(1)
O(2) -0.33696	O(2)
H(3) 0.18429	H(3)

H(4) 0.18583 H(4)
H(7) 0.26278 H(7)
H(5) -0.01204 H(5)
H(6) 0.01233 H(6)

Removing lone pairs for MOPAC computation

Spectral Analysis

Vibration 1: Frequency: -89.208584

Atom Displacement:	X	Y	Z
Atom 1 :	-0.003843	-0.000143	-0.020534
Atom 2 :	-0.004095	-0.006755	0.002099
Atom 3 :	0.000265	0.000351	0.012382
Atom 4 :	-0.005688	-0.017392	-0.014632
Atom 5 :	0.001847	0.012004	-0.007625
Atom 6 :	0.275530	0.208313	0.222212
Atom 7 :	-0.241312	-0.175830	-0.144153

Vibration 2: Frequency: -88.574571

Atom Displacement:	X	Y	Z
Atom 1 :	-0.008462	0.017490	0.005359
Atom 2 :	-0.009080	-0.002927	0.003410
Atom 3 :	0.001640	0.005903	-0.020438
Atom 4 :	-0.003553	0.026128	0.010316
Atom 5 :	-0.004729	-0.018039	0.011506
Atom 6 :	0.244467	-0.337183	0.014667
Atom 7 :	-0.170104	0.269655	-0.049616

16 measurements			
Atoms	Actual	Optimal	
□ N(1)-O(2)	1.316	-	
□ N(1)-H(3)	1.028	-	
□ N(1)-H(4)	1.028	-	
□ O(2)-H(7)	0.992	-	
□ H(5)-H(6)	0.704	-	
□ N(1),H(5)	0.668	-	
□ N(1),H(6)	1.372	-	
□ O(2),H(5)	1.984	-	
□ H(3),H(5)	1.022	-	
□ H(3),H(6)	1.413	-	
□ H(4),H(5)	1.022	-	
□ H(4),H(6)	1.413	-	
□ O(2)-N(1)-H(3)	109.500	-	
□ O(2)-N(1)-H(4)	109.500	-	
□ H(3)-N(1)-H(4)	109.500	-	
□ N(1)-O(2)-H(7)	109.500	-	

Gambar 4. Jarak antara atom pada molekul NH_4OH dengan menggunakan measurements (Raber, D.J., et. al. JOC, 1989, 54, 5032-5035)

Amonium hidroksida (NH_4OH) memiliki ikatan ionik dan kovalen. Antara NH_4^+ dan OH^- berikatan ion^(115, 118, 130-135). Sedangkan atom-atom dalam NH_4OH berikatan kovalen⁽¹³⁶⁻¹⁴⁵⁾. Ketika NH_4^+ direaksikan dengan OH^- , maka senyawa NH_4^+ akan menarik elektron dari OH^- . Dengan demikian, akibat adanya perbedaan muatan dari ion-ion NH_4OH mengakibatkan ion-ion tersebut tarik-menarik sehingga membentuk senyawa NH_4OH .

Gambar 5. Reaksi antara NH_4^+ dengan OH^- dengan menggunakan lambang Lewis⁽⁹⁷⁾

Ikatan kovalen koordinasi dalam ion NH_4^+ terbentuk dari reaksi antara NH_3 dengan ion H^+ . Atom N dalam NH_3 mempunyai sepasang elektron bebas, sementara ion H^+ sudah tidak mempunyai elektron. Elektron bebas dari atom N kemudian digunakan bersama dengan ion H^+ .

Gambar 6. Ikatan Kovalen Koordinasi NH_4^+ ⁽⁴⁷⁾

Amonium hidroksida terdiri dari kation amonium dan anion hidroksida. Pada kation amonium jarak antara atom N-H adalah 0,101 nm dan jarak H-H adalah 0.165 nm. Sudut yang dibentuk dari kation amonium yaitu sebesar $109,5^\circ$. Sedangkan jarak antara atom O-H dalam anion hidrksida yaitu sebesar 0,097 nm⁽⁹³⁾. Seperti yang terlihat pada gambar dibawah ini

Gambar 7. Bentuk Bola dan Pasak (a) Kation Amonium (b) Anion Hidroksida
https://en.wikipedia.org/wiki/Ammonia_solution

c) Konduktivitas

Amonium hidroksida juga mempunyai konduksitas. Konduktivitas digunakan untuk mengukur daya hantar larutan atau cairan elektrolit. Besarnya konduktivitas ditentukan oleh konsentrasi elektrolit^(17, 146-159). Energi listrik dapat di transfer melalui materi berupa hantaran yang bermuatan listrik yang berwujud arus listrik yang berarti bahwa harus ada pembawa muatan listrik di dalam materi serta adanya gaya yang menggerakkan pembawa muatan tersebut^(57, 68-73). Pembawa muatan dapat berupa elektron seperti logam atau dapat juga digunakan ion positif dan ion negatif seperti dalam larutan elektrolit dan lelehan garam. Gaya listrik yang membuat muatan bergerak biasanya berasal dari baterai, generator atau sumber energy listrik yang lain. Muatan listrik akan berpindah jika terdapat beda potensial diantara dua tempat tersebut. Arus listrik akan mengalir atau berpindah dari tempat yang berpotensi tinggi menuju tempat dengan potensial yang lebih rendah. Arus listrik terjadi didalam suatu larutan karena adanya ion yang bergerak. Berdasarkan data eksperimen dari larutan NH_4OH adalah sebagai berikut:

Tabel 1. Data Daya Hantar Listrik NH_4OH pada Konsentrasi Tertentu

No.	Konsentrasi	I (mA)	V (Volt)	Hambatan (Ω)	Daya Hantar Listrik (Ω^{-1})
1.	0,10 M	0,39	2,0	5128,20	$1,95 \times 10^{-4}$
2.	0,15 M	0,47	2,0	4255,32	$2,35 \times 10^{-4}$
3.	0,20 M	0,52	2,0	3846,15	$2,60 \times 10^{-4}$
4.	0,25 M	0,57	2,0	3508,77	$2,85 \times 10^{-4}$
5.	0,30 M	0,62	2,0	3225,80	$3,10 \times 10^{-4}$

Sehingga dari data tersebut didapat grafik konduktivitas dari larutan NH_4OH

Dari tabel dan grafik diatas dapat disimpulkan bahwa semakin besar konsentrasi larutan NH_4OH maka konduktifitasnya juga semakin besar⁽⁹³⁾.

d) Termokimia

Termokimia ialah cabang kimia yang berhubungan dengan hubungan timbal balik panas dengan reaksi kimia atau dengan perubahan keadaan fisika. Secara umum,

termokimia ialah penerapan termodinamika untuk kimia. Termokimia ialah sinonim dari termodinamika kimia. Termokimia larutan NH_4OH dibagi menjadi dua, yaitu entropi molar standar dan entalpi molar standar^(66, 67).

Entropi molar standar atau yang biasa disimbolkan dengan S^0 merupakan entropi satu mol suatu senyawa pada keadaan standar (bukan dalam STP). Entropi molar standar mempunyai satuan Joule per mol kelvin (J/molK). Nilai S^0 bersifat absolut, tidak seperti entalpi pembentukan⁽¹⁶⁰⁻¹⁶⁵⁾. Dimana keadaan standar suatu unsur nilainya tidak sama dengan nol yang pasti S berada pada suhu ruangan. Struktur kristal murni mempunyai nilai entropi 0 J/molK pada suhu 0 K , menurut hukum termodinamika ketiga⁽¹⁶⁶⁻¹⁶⁹⁾.

Besarnya perubahan entalpi pembentukan standar dari suatu senyawa adalah 1 mol senyawa dari unsur-unsurnya pada keadaan standar. Entalpi pembentukan standar disimbolkan dengan ΔH_f^0 atau $\Delta_f H^0$. Perubahan entalpi pembentukan standar diperoleh dari energi per satuan unit substansi^(170, 171). Satuan ΔH_f^0 adalah kJoule per mol (kJ/mol), atau bisa juga diperoleh dalam satuan kalori per mol, Joule per mol, atau kilo kalori per mol. Dalam ilmu fisika, energi per partikel sering dituliskan dalam satuan elektronvolt yang hasilnya kurang lebih 100 kJ mol^{-1} .

Besarnya energi bebas Gibbs pada pembentukan satu mol senyawa dari unsur-unsurnya dalam keadaan standar (pada suhu 25°C dan tekanan 100 kPa) disebut energi bebas Gibbs⁽²⁵⁸⁻²⁶³⁾. Energi bebas Gibbs disimbolkan dengan $\Delta_f G^0$. Dalam keadaan standar semua unsur mempunyai energi bebas Gibbs pembentukan standar sama dengan nol, seperti tidak terjadi reaksi apapun^(172, 173).

$$\Delta_r G = \Delta_f G^0 + RT \ln Q_f ; Q_f \text{ adalah hasil bagi reaksi.}$$

Pada kesetimbangan, $\Delta_r G = 0$ dan $Q_f = K$ sehingga persamaan menjadi:

$$\Delta_r G^0 = -RT \ln K ; K \text{ adalah konstanta kesetimbangan}^{(93)}.$$

Tabel 2. Standar Termodinamika Bahan Kimia

Nama	$\Delta H^0 \left(\frac{\text{kJ}}{\text{mol}} \right)$			$\Delta G^0 \left(\frac{\text{kJ}}{\text{mol}} \right)$			$S^0 \left(\frac{\text{J}}{\text{molK}} \right)$			$C_p \left(\frac{\text{J}}{\text{molK}} \right)$		
	Crys	Liq	Gas	Crys	Liq	Gas	Crys	Liq	Gas	Crys	Liq	Gas
Amonium Hydroxide		-361.2			-254.0			165.6			154.9	
Amonium Hydrogen Sulfite	-768.6											
Amonium Hydrogen Sulfate	-1027.0											
Amonium Sulfate	-1180.9			-901.7			220.1			187.5		

e) Mobilitas

Berikut ini akan dibahas teknik penentuan mobilitas beberapa jenis ion antara lain ion-ion Ar^+ , OH^- , H^+ , CO_2^+ dan O_2^- . Untuk menentukan mobilitas ion-ion terlebih dahulu akan dibahas, pendekatan Robinson dan pendekatan Choelo untuk menjelaskan hubungan arus ion (arus korona) terhadap tegangan dan kaitannya dengan unsur mikroskopik masalah-masalah transpor partikel bermuatan dalam plasma korona⁽⁵⁵⁻⁵⁹⁾.

• Pendekatan Umum Robinson

Robinson pada tahun 1961, telah mencari hubungan dasar tiga parameter utama yakni laju u , tegangan V , kuat arus korona (masing dalam ms^{-1} , volt dan ampere). Untuk jarak antar elektroda tertentu dapat dituliskan menjadi.

$$u \propto V \propto i^{1/2}$$

Untuk mendapatkan kaitan antara kuat arus, jarak antar elektroda, tegangan, kuat arus korona yang sering juga disebut angin korona diperoleh dengan menggunakan hukum

Gauss⁽²⁵⁰⁻²⁵⁸⁾. Diperoleh hubungan antara medan listrik dengan disipasi daya untuk tegangan V dan kuat arus i :

$$Vi = xy\mu\epsilon_0 E \int_0^d (\nabla \cdot E) Edz$$

dengan x, y, z adalah variabel dimensi dalam arah horizontal, longitudinal dan vertikal, d adalah jarak elektroda pada bidang z (semua dalam mm). E adalah kuat medan elektrostatis ($V m^{-1}$). μ adalah mobilitas ion ($m^2 V^{-1} s^{-1}$) dan ϵ_0 permitivitas listrik udara ($F m^{-1}$)⁽¹⁷⁴⁻¹⁷⁸⁾.

- **Pendekatan Hiperbolik Bidang**

Pada tahun 1971 Choelo melakukan analisis terhadap hubungan arus korona, tegangan, jarak antar elektroda untuk sistem elektroda yang menghasilkan medan tak simetris. Dalam kondisi lucutan korona ion yang mengalir adalah satu jenis ion (unipolar). Berbeda dengan kondisi lucutan *arc* muatan yang mengalir dapat ion positif, ion negatif dan elektron (bipolar). Arus ion unipolar dengan mobilitas μ mengalir dengan rapat muatan $\rho(r, t)$ dan rapat arus $j = \rho v$ tanpa mengalami difusi dalam medan listrik $E(r, t)$. perubahan rapat muatan (ρ) sepanjang aliran adalah:

$$\frac{d\rho}{dt} = \frac{\partial \rho}{\partial t} + v \cdot \nabla \rho$$

Berikut adalah Sketsa lucutan korona positif konfigurasi elektroda hiperbolik (titik)-bidang.

Gambar 8. Sketsa lucutan korona positif konfigurasi elektroda hiperbolik (titik)-bidang⁽⁴⁶⁾

Pendekatan Robinson (1961) melalui medan simetris dan Choelo (1971) khusus untuk elektroda hiperbolik bidang (umumnya juga menghasilkan medan yang simetris) menghasilkan perumusan yang sama. Dengan menggunakan data eksperimen hubungan antara arus dan tegangan, dan menggunakan perumusan Robinson dan Choelo mobilitas dan laju pembawa muatan dapat ditentukan⁽¹⁷⁹⁾.

Dalam penelitian ini telah ditentukan mobilitas ion Ar^+ , CO_2^- , O_2^- dan, OH^- , H^+ . Khusus untuk OH^- dan H^+ merupakan mobilitas rata-rata kedua ion pembawa muatan tersebut keseluruhan hasil penentuan mobilitas yang diperoleh dalam penelitian ini diberikan dalam tabel berikut⁽²⁴¹⁻²⁴⁹⁾.

Tabel 3. Hasil mobilitas ion Ar^+ , CO_2^+ , O_2^- , H^+ dan OH^-

Jenis Gas	Jenis Ion	Nilai Mobilitas (cm^2/Vs)	Mobilitas hasil Peneliti Lain (cm^2/Vs)	Tekanan (atm)	Elektroda yang digunakan Peneliti Lain
Argon	Ar^+	1.423	1.565	1	Boew, 1960
Karbon Dioksida	CO_2^-	0.988		1	bidang-bidang Allen dan Prew, 1970 Bidang-bidang
Uap Air	H^+ , OH^-	3.558	1.093	1	
Oksigen	O_2^-	3.95×10^{-2}	4.12×10^{-2}	1	Nur et al, 1997

Jika mobilitas ion OH^- dapat ditentukan dengan pendekatan Robinson dan Hiperbolik Bidang, maka untuk NH_4^+ dapat ditentukan dengan metode pemisahan dan pengukuran dengan elektrometri dan spektrofotometri. Dimana mobilitas ion NH_4 dapat dilihat dari tabel berikut⁽²³²⁻²⁴¹⁾.

Tabel 4. Mobilitas Relatif dari Ion

	Nama Ion	Valensi	Mobilitas Ion
Cs	Cesium	1	1,05
K	Kalium	1	1
Li	Litium	1	0,525
NH_4	Amonium	1	1
Na	Natrium	1	0,682
F	Flourida	-1	0,753
I	Iod	-1	1,045
Ba	Barium	2	0,433
Co	Cobal	2	0,37
Pb	Timbal	3	0,48
Fe	Besi	3	0,313; 0,308

f) Kecepatan Hanyut

Jika dua elektroda yang terpisah dengan jarak l berada pada selisih potensial $\Delta\phi$, maka ion dalam larutan di antara kedua elektroda itu, mengalami medan listrik seragam yaitu:

$$E = \frac{\Delta\phi}{l} \quad (1)$$

Dalam medan demikian, ion yang bermuatan ze mengalami gaya sebesar :

$$I_e = zeE = \frac{ze\Delta\phi}{l} \quad (2)$$

Kation bereaksi dengan percepatan menuju elektroda negative dan anion bereaksi dengan percepatan menuju elektroda positif⁽²²¹⁻²³²⁾. Akan tetapi, saat ion bergerak melalui pelarut maka ion akan mengalami gaya gesekan memperlambat I_e yang sebanding dengan kecepatannya. Jika diasumsikan bahwa hukum Stokes untuk bola radius a dan s berlaku pada skala mikroskopis, maka kita dapat menuliskan gaya perlambatan ini sebagai:

$$I_e' = fs = 6\pi\eta a \quad (3)$$

karena kecepatan hanyut mengatur laju transportasi ion, maka dapat diharapkan konduktivitas akan berkurang dengan bertambahnya viskositas pelarut akan ukuran ion⁽⁷⁹⁻⁸⁴⁾.

Jika potensial NH_4OH adalah 2,0 V dan jarak antar elektroda adalah 4 cm, maka kecepatan hanyutnya dapat dihitung dengan rumus

$$E = \frac{\Delta\phi}{l}$$

$$E = \frac{2}{4} = 0,5$$

Jadi kecepatan hanyut NH_4OH adalah 0,5 V/cm

g) Viskositas Kinematik

Konsep dasar viskositas kinematik adalah perkembangan dari penggunaan cairan untuk menghasilkan aliran melalui suatu tabung kapiler. Koefisien viskositas absolut, apabila dibagi oleh kerapatan fluidanya disebut viskositas kinematik⁽¹⁸⁰⁻¹⁸⁴⁾. Dalam sistem metrik satuan viskositas disebut Stoke dan mempunyai satuan centimeter kuadrat per detik. Biasanya didapatkan satuan perbandingan yang lebih kecil yaitu centistoke dan besarnya sama dengan seperseratus stoke⁽⁶⁰⁻⁶⁵⁾. Apabila dikonversikan antara viskositas absolut dan kinematik didapatkan perbandingan :

$$\text{Viskositas kinematik (Vk)} = \frac{\text{Viskositas Absolut } (\mu)}{\text{Kerapatan } (\rho)}$$

Dinyatakan dalam SI, viskositas kinematik adalah :

$$\text{Viskositas kinematik (Vk)} = \frac{\text{Dyne} \cdot \text{detik} / \text{cm}^2}{\text{Dyne} \cdot \text{detik}^2 / \text{cm}^4} = \text{cm}^2 / \text{detik}$$

Dinyatakan sebagai satuan Stoke (S) setelah Gabriel Stokes menemukan dasar tentang dinamika fluida. Satuan stoke adalah terlalu besar untuk jenis fluida yang digunakan dalam hidrolika industri, dan viskositas kinematik yang dinyatakan dalam satuan SI diberikan dalam skala yang lebih kecil yaitu centistoke⁽¹⁸⁵⁻¹⁹²⁾. Untuk amonium hidroksida (NH_4OH) mempunyai viskositas kinematik sebesar 1,12 cSt⁽²¹²⁻²²⁰⁾.

h) Kegunaan

➤ Pembersih Rumah Tangga

Amonium hidroksida encer juga digunakan sebagai pembersih rumah tangga, termasuk pembersih lantai, kaca, dll. Selain itu amonium hidroksida dapat menjadi distributor terhadap dirinya sendiri, biasanya dijual dengan merek "amonia". Amonium hidroksida dapat dijual dalam bentuk murni, beraroma lemon (kuning), atau beraroma pinur

(hijau). Amonia biasanya digunakan dalam pembuatan sabun atau sering di sebut dengan “Cloudy-Ammonia”⁽⁸⁵⁻⁸⁸⁾.

➤ **Alkil Amina**

Amonium hidroksida dalam dunia industri biasanya digunakan sebagai bahan dasar pembuatan alkil amina, walaupun amonia anhidrat yang sering digunakan. Hasil reaksi dari amonium hidroksida dan formaldehid adalah heksametilenatetraamina. Dan untuk hasil reaksi amonium hidroksida dan 1,2-dikloroetana adalah etilendiamina⁽³⁹⁾.

➤ **Pewarnaan Prabot**

Amonium hidroksida juga dapat digunakan dalam pembuatan prabot untuk menggelapkan atau berwarna kayu yang mengandung asan tanat. Asam tanat dengan garam besi yang ditemukan didalam kayu akan bereaksi dengan asap amonium hidroksida sehingga menghasilkan kayu yang berkualitas bagus. Cara ini biasanya dilakukan dalam dunia seni dan kerajinan tangan.^(87, 88)

➤ **Produksi Pangan**

Amonium hidroksida juga merupakan agen antimikroba yang efektif karena kemampuannya dalam sebagai larutan penyangga. Selain itu, amonium hidroksida juga diklasifikasikan oleh Food and Drug Administration sebagai umumnya aman (GRAS)⁽⁷⁴⁻⁷⁸⁾.

➤ **Pengolahan Tembakau**

Untuk meningkatkan rasa dan sebagai bantuan dalam pengolahan tembakau maka digunakan 0,3% amonium hidroksida, menurut Philip Morris USA^(87, 88).

➤ **Perlakuan Jerami, untuk Ternak**

Dalam memudahkan merawat atau memproduksi jerami “Jeramo teramonisasi maka dapat digunakan amonium hidroksida sehingga memudahkan binatang ternak memakanny^(87, 88).

➤ **Penggunaan Laboratorium**

Amonium hidroksida dalam analisis anorganik biasanya sebagai pengmples dan basa. Amonium hidroksida memberikan warna biru tua juga dilarutkan dengan tembaga (II). Larutan amonia jika bereaksi dengan pereaksi Tollens akan menghasilkan perak oksida. Larutan ini dapat dijumpai pada penyepuhan emas, perak, dan perhiasan platina. Tetapi larutan ini mempunyai efek negatif pada batu permata berpori seperti oval dan mutiara. Bila amonium hidroksida dicampurkan dengan hidrogen peroksida encer dengan katalis Cu^{2+} , maka peroksida akan terdekomposisi dengan cepat⁽⁴⁴⁾.

i) **Bahaya**

(a)

(b)

Gambar 7. (a) Beracun dalam lingkungan, (b) Korosif

https://en.wikipedia.org/wiki/Ammonia_solution

Tabel 5. Bahaya dan Pertolongan Pertama jika terkena NH_4OH

Bahaya		Identifikasi Pertolongan Pertama
Mata	: Kontak dengan luka bakar cair atau uap penyebab dan kemungkinan kerusakan mata permanen. Lachrymator (senyawa yang meningkatkan aliran air mata).	Dalam kasus kontak, segera basuh mata dengan banyak air selama 15 menit. Dapatkan bantuan medis segera mungkin
Kulit	: Menyebabkan gangguan pada kulit. Menyebabkan luka bakar kulit. Dapat menyebabkan mendalam, menebus borok dari kulit. Kontak dengan kulit dapat menyebabkan pewarnaan, peradangan, dan penebalan kulit	Dalam kasus kontak, segera siram kulit dengan banyak air selama 15 menit sambil melepaskan pakaian dan sepatu yang terkontaminasi. Dapatkan bantuan medis dengan segera. Mencuci pakaian sebelum digunakan kembali
Tertelan	: Berbahaya jika tertelan. Dapat menyebabkan kerusakan parah dan permanen pada saluran pencernaan. Menyebabkan luka bakar saluran pencernaan. Penyebab tenggorokan penyempitan, muntah, kejang, dan shock	Jika tertelan, jangan dimuntahkan. Dapatkan bantuan medis dengan segera. Bila korban tidak sepenuhnya sadar, membersihkan secangkir air. Dilarang memberikan apapun melalui mulut kepada orang sadar
Inhalasi	: Efek mungkin tertunda. Menyebabkan iritasi parah dari saluran pernapasan bagian atas dengan batuk, luka bakar, kesulitan bernafas, dan kemungkinan koma ^(27, 28)	Jika terhirup, pindahkan ke udara segar. Jika tidak bernapas, berikan pernapasan bantuan. Jika napas sulit, berikan oksigen. Dapatkan bantuan medis ^(96, 193-211) . Catatan dokter : Setelah paparan inhalasi, amati selama 24 s.d 72 jam sebagai edema paru mungkin tertunda

4. Kesimpulan

Amonium hidroksida mempunyai ikatan kovalen dan ikatan ion didalam air. Mempunyai bentuk tetrahedral dan juga mempunyai konduktifitas, dimana jika konsentrasi NH_4OH meningkat maka konduktivitas juga meningkat. Amonium hidroksida mempunyai termokimia dalam fase liquid dengan $\Delta H, \Delta G, S^\circ$, dan C_p yang masing-masing mempunyai nilai -361.2 kJ/mol, -254.0 kJ/mol, 165.6 J/molK dan 154.9 J/molK. Mobilitas ion NH_4 dan OH^- adalah 3.5 dan 1. Amonium hidroksida juga mempunyai energi kinetik yang hasilnya dapat diketahui dengan menggunakan *chemoffice 15.0* yaitu sebesar 0,43. Selain sifat fisika dan kimia, NH_4OH mempunyai bahaya jika terkena alat indra. Untuk itu sebelum menggunakan NH_4OH alangkah lebih baik jika kita mengetahui msds nya.

Referensi

1. Liu X, Ge L, Li W, Wang X, Li F. Layered double hydroxide functionalized textile for effective oil/water separation and selective oil adsorption. *ACS applied materials & interfaces*. 2015;7(1):791-800.
2. Soniat M, Kumar R, Rick SW. Hydrated proton and hydroxide charge transfer at the liquid/vapor interface of water. *The Journal of chemical physics*. 2015;143(4):044702.
3. Taborosi A, Szilagyi RK. Behaviour of the surface hydroxide groups of exfoliated kaolinite in the gas phase and during water adsorption. *Dalton transactions*. 2016;45(6):2523-35.
4. Tse YL, Chen C, Lindberg GE, Kumar R, Voth GA. Propensity of Hydrated Excess Protons and Hydroxide Anions for the Air-Water Interface. *Journal of the American Chemical Society*. 2015;137(39):12610-6.
5. Aldarf M, Amrane A, Prigent Y. Reconstruction of the biomass history from carbon and nitrogen substrate consumption, ammonia release and proton transfer during solid cultures of *Geotrichum candidum* and *Penicillium camembertii*. *Applied microbiology and biotechnology*. 2002;58(6):823-9.
6. Bergmann DJ, Hooper AB, Klotz MG. Structure and sequence conservation of hao cluster genes of autotrophic ammonia-oxidizing bacteria: evidence for their evolutionary history. *Applied and environmental microbiology*. 2005;71(9):5371-82.
7. Cao H, Lyu K, Xiang F, Yang Z. Life history responses of *Daphnia similis* simultaneously exposed to microcystin-LR and ammonia and their postexposure recovery. *Environmental toxicology and chemistry*. 2014;33(11):2497-505.
8. Lyu K, Cao H, Chen R, Wang Q, Yang Z. Combined effects of hypoxia and ammonia to *Daphnia similis* estimated with life-history traits. *Environmental science and pollution research international*. 2013;20(8):5379-87.
9. Monteiro M, Seneca J, Magalhaes C. The history of aerobic ammonia oxidizers: from the first discoveries to today. *Journal of microbiology*. 2014;52(7):537-47.
10. Mundepe A, Norton J, Cabrera M, Franklin D, Habteselassie MY. Ammonia Oxidizers in a Grazing Land with a History of Poultry Litter Application. *Journal of environmental quality*. 2017;46(5):994-1002.
11. Yang Z, Lu K, Chen Y, Montagnes DJ. The interactive effects of ammonia and microcystin on life-history traits of the cladoceran *Daphnia magna*: synergistic or antagonistic? *PloS one*. 2012;7(3):e32285.
12. Audubert C, Bouchard A, Mathieu G, Lebel H. Chemoselective Synthesis of Amines from Ammonium Hydroxide and Hydroxylamine in Continuous Flow. *The Journal of organic chemistry*. 2018.
13. An S, Li W, Liu Q, Xia Y, Zhang T, Huang F, et al. Combined dilute hydrochloric acid and alkaline wet oxidation pretreatment to improve sugar recovery of corn stover. *Bioresource technology*. 2019;271:283-8.
14. Liu ZW, Chen C, Peng XC, Xie WM, Huang ZY, Han QJ. [Effect of Magnetic Chitosan Hydrogel Beads with Immobilized Feammox Bacteria on the Removal of Ammonium from Wastewater]. *Huan jing ke xue= Huanjing kexue*. 2018;39(10):4601-11.
15. Park SJ, Park JY, Yang HK, Moon BK, Oh J. Biocompatible sphere, square prism and hexagonal rod Gd₂O₃:Eu(3+)₃@SiO₂ nanoparticles: The effect of morphology on multi-modal imaging. *Colloids and surfaces B, Biointerfaces*. 2018;172:224-32.
16. Sazawa K, Yoshida H, Okusu K, Hata N, Kuramitz H. Effects of forest fire on the properties of soil and humic substances extracted from forest soil in Gunma, Japan. *Environmental science and pollution research international*. 2018;25(30):30325-38.

17. Ding S, Chu W, Krasner SW, Yu Y, Fang C, Xu B, et al. The stability of chlorinated, brominated, and iodinated haloacetamides in drinking water. *Water research*. 2018;142:490-500.
18. Chaturvedi N, Hsiao E, Velegol D, Kim SH. Maskless fabrication of nanowells using chemically reactive colloids. *Nano letters*. 2011;11(2):672-6.
19. Kalita SJ, Verma S. Nanocrystalline hydroxyapatite bioceramic using microwave radiation: Synthesis and characterization. *Materials science & engineering C, Materials for biological applications*. 2010;30(2):295-303.
20. Kim HS, Park NK, Lee TJ, Kang M. Synthesis of Cubic Alpha-Alumina Using a Blocking Reagent of Tetraethyl Ammonium Hydroxide. *Journal of nanoscience and nanotechnology*. 2015;15(2):1383-8.
21. Cohen SW. A history of oxygen permeability. *Contact lens & anterior eye : the journal of the British Contact Lens Association*. 1998;21(2):35-40.
22. Dole M. The natural history of oxygen. *The Journal of general physiology*. 1965;49(1):Suppl:5-27.
23. Dowling DK, Simmons LW. Reactive oxygen species as universal constraints in life-history evolution. *Proceedings Biological sciences*. 2009;276(1663):1737-45.
24. Koehler N, Goubeaud M, Hildebrandt O, Sohrabi AK, Koehler U. [The history of oxygen--from its discovery to its implementation as medical therapy]. *Pneumologie*. 2011;65(12):736-41.
25. Koehler N, Goubeaud M, Hildebrandt O, Sohrabi AK, Koehler U. [The History of Oxygen - From its Discovery to its Implementation as Medical Therapy]. *Pneumologie*. 2016;70(S 02):S149-S54.
26. Sadoul P. [History of oxygen therapy]. *La Revue du praticien*. 2000;50(19):2096-100.
27. Constanzer ML, Chavez-Eng CM, Fu I, Woolf EJ, Matuszewski BK. Determination of dextromethorphan and its metabolite dextrorphan in human urine using high performance liquid chromatography with atmospheric pressure chemical ionization tandem mass spectrometry: a study of selectivity of a tandem mass spectrometric assay. *Journal of chromatography B, Analytical technologies in the biomedical and life sciences*. 2005;816(1-2):297-308.
28. Ge JW, Liu SX, Zhang CF, Li Q, Xia JM, Xu YZ, et al. [Investigation of thermal behaviors of gamma-form nylon 6 prepared by ammonia vapor from phosphoric acid solutions]. *Guang pu xue yu guang pu fen xi = Guang pu*. 2012;32(1):118-22.
29. Baechle B, Davis AS, Pittelkow CM. Potential Nitrogen Losses in Relation to Spatially Distinct Soil Management History and Biochar Addition. *Journal of environmental quality*. 2018;47(1):62-9.
30. Baldani JJ, Baldani VL. History on the biological nitrogen fixation research in graminaceous plants: special emphasis on the Brazilian experience. *Anais da Academia Brasileira de Ciencias*. 2005;77(3):549-79.
31. Broda E. The history of inorganic nitrogen in the biosphere. *Journal of molecular evolution*. 1975;7(1):87-100.
32. Cissik JH, Johnson RE. Myth of nitrogen equality in respiration: its history and implications. *Aerospace medicine*. 1972;43(7):755-8.
33. Ericson LE. [Aspects of nitrogen metabolism in higher animals; history & basic concepts]. *Svenska lakartidningen*. 1957;54(36):2621-46.
34. Henson BJ, Watson LE, Barnum SR. The evolutionary history of nitrogen fixation, as assessed by NifD. *Journal of molecular evolution*. 2004;58(4):390-9.
35. Huberty AF, Denno RF. Consequences of nitrogen and phosphorus limitation for the performance of two planthoppers with divergent life-history strategies. *Oecologia*. 2006;149(3):444-55.
36. McElroy MB, Yung YL, Nier AO. Isotopic composition of nitrogen: implications for the past history of mars' atmosphere. *Science*. 1976;194(4260):70-2.

37. Perren BB, Axford Y, Kaufman DS. Alder, Nitrogen, and Lake Ecology: Terrestrial-Aquatic Linkages in the Postglacial History of Lone Spruce Pond, Southwestern Alaska. *PloS one*. 2017;12(1):e0169106.
38. Raymond J, Siefert JL, Staples CR, Blankenship RE. The natural history of nitrogen fixation. *Molecular biology and evolution*. 2004;21(3):541-54.
39. Sackett DK, Drazen JC, Popp BN, Choy CA, Blum JD, Johnson MW. Carbon, Nitrogen, and Mercury Isotope Evidence for the Biogeochemical History of Mercury in Hawaiian Marine Bottomfish. *Environmental science & technology*. 2017;51(23):13976-84.
40. Wang JH, Devalia JL, Duddle JM, Hamilton SA, Davies RJ. Effect of six-hour exposure to nitrogen dioxide on early-phase nasal response to allergen challenge in patients with a history of seasonal allergic rhinitis. *The Journal of allergy and clinical immunology*. 1995;96(5 Pt 1):669-76.
41. Yersin BR, Glauser MP, Freedman LR. Effect of nitrogen mustard on natural history of right-sided streptococcal endocarditis in rabbits: role for cellular host defenses. *Infection and immunity*. 1982;35(1):320-5.
42. Chen N, Long C, Li Y, Lu C, Zhu H. Ultrastable and High Ion-Conducting Polyelectrolyte Based on Six-Membered N-Spirocyclic Ammonium for Hydroxide Exchange Membrane Fuel Cell Applications. *ACS applied materials & interfaces*. 2018;10(18):15720-32.
43. Dahiya AS, Boubenia S, Franzo G, Poulin-Vittrant G, Mirabella S, Alquier D. Photoluminescence Study of the Influence of Additive Ammonium Hydroxide in Hydrothermally Grown ZnO Nanowires. *Nanoscale research letters*. 2018;13(1):249.
44. Duan X, Zhang X, Zhang Y. High Performance Organic-Nanostructured Silicon Hybrid Solar Cell with Modified Surface Structure. *Nanoscale research letters*. 2018;13(1):283.
45. Guo Y, Wu C, Xu L, Xu Y, Xiaohong L, Hui Z, et al. Vascularization of pancreatic decellularized scaffold with endothelial progenitor cells. *Journal of artificial organs : the official journal of the Japanese Society for Artificial Organs*. 2018;21(2):230-7.
46. Sakagami H, Tsuji M, Tomomura M, Masuda Y, Iwama S, Nakagawa M, et al. Protection of Differentiating Neuronal Cells from Amyloid beta Peptide-induced Injury by Alkaline Extract of Leaves of *Sasa senanensis* Rehder. *In vivo*. 2018;32(2):231-9.
47. Ye B, Lu Y, Luo H, Liu G, Zhang R. Tetramethyl ammonium hydroxide production using the microbial electrolysis desalination and chemical-production cell with long anode. *Bioresource technology*. 2018;251:403-6.
48. Zhang X, Peng W, Han L, Xiao W, Liu X. Effects of different pretreatments on compression molding of wheat straw and mechanism analysis. *Bioresource technology*. 2018;251:210-7.
49. Bethe HA. Hydrogen bomb history. *Science*. 1982;218(4579):1270.
50. Cunningham ML, Seto ML, Ratisoontorn C, Heike CL, Hing AV. Syndromic craniosynostosis: from history to hydrogen bonds. *Orthodontics & craniofacial research*. 2007;10(2):67-81.
51. Fowler WA. Nuclear Clues to the Early History of the Solar System: Light nuclei were synthesized before planetary material had entirely separated from hydrogen. *Science*. 1962;135(3508):1037-45.
52. Mant M, Nagel A, Prowse T. Investigating Residential History Using Stable Hydrogen and Oxygen Isotopes of Human Hair and Drinking Water. *Journal of forensic sciences*. 2016;61(4):884-91.

53. Miller SM, Klinman JP. Deduction of kinetic mechanisms from primary hydrogen isotope effects: dopamine beta-monooxygenase--a case history. *Methods in enzymology*. 1982;87:711-32.
54. Teller E. Hydrogen bomb history. *Science*. 1982;218(4579):1270.
55. Chen YP, Wang SF, Jia YF. [Chemical extraction of arsenic co-precipitated with amorphous Fe (OH)₃ and Fe₃O₄]. *Huan jing ke xue= Huanjing kexue*. 2013;34(1):308-14.
56. do Rego Monteiro VA, de Souza EF, de Azevedo MM, Galembeck F. Aluminum Polyphosphate Nanoparticles: Preparation, Particle Size Determination, and Microchemistry. *Journal of colloid and interface science*. 1999;217(2):237-48.
57. He G, Xu M, Li Z, Wang S, Jiang S, He X, et al. Highly Hydroxide-Conductive Nanostructured Solid Electrolyte via Predesigned Ionic Nanoaggregates. *ACS applied materials & interfaces*. 2017;9(34):28346-54.
58. Hwang S, Lee EJ, Song D, Jeong NC. High Proton Mobility with High Directionality in Isolated Channels of MOF-74. *ACS applied materials & interfaces*. 2018.
59. Krivankova L, Brezkova M, Gebauer P, Bocek P. Importance of the counterion in optimization of a borate electrolyte system for analyses of anions in samples with complex matrices performed by capillary zone electrophoresis. *Electrophoresis*. 2004;25(20):3406-15.
60. Clifton M, Nguyen T, Frost R. Effect of ionic surfactants on bauxite residues suspensions viscosity. *Journal of colloid and interface science*. 2007;307(2):572-7.
61. Gubitosi M, Duarte H, Gentile L, Olsson U, Medronho B. On cellulose dissolution and aggregation in aqueous tetrabutylammonium hydroxide. *Biomacromolecules*. 2016;17(9):2873-81.
62. Misselt AJ, Edelman TL, Choi JH, Bischof JC, Cressman EN. A hydrophobic gel phantom for study of thermochemical ablation: initial results using a weak acid and weak base. *Journal of vascular and interventional radiology : JVIR*. 2009;20(10):1352-8.
63. Shen X, Gao B, Huang X, Bu F, Yue Q, Li R, et al. Effect of the dosage ratio and the viscosity of PAC/PDMDAAC on coagulation performance and membrane fouling in a hybrid coagulation-ultrafiltration process. *Chemosphere*. 2017;173:288-98.
64. Wan LS. Effects of acids and bases on salicylic acid-cetrimide systems. *Journal of pharmaceutical sciences*. 1975;64(6):1037-9.
65. Wang Y, Gao B, Yue Q, Wang Y. Effect of viscosity, basicity and organic content of composite flocculant on the decolorization performance and mechanism for reactive dyeing wastewater. *Journal of environmental sciences*. 2011;23(10):1626-33.
66. Kulkarni PB, Purandare GN, Nair JK, Talawar MB, Mukundan T, Asthana SN. Synthesis, characterization, thermolysis and performance evaluation studies on alkali metal salts of TABA and NTO. *Journal of hazardous materials*. 2005;119(1-3):53-61.
67. Yan X, Lei Z. Silicon dioxide hollow microspheres with porous composite structure: synthesis and characterization. *Journal of colloid and interface science*. 2011;362(2):253-60.
68. de Castro Costa BM, Marra MC, da Costa Oliveira T, Munoz RAA, Batista AD, do Lago CL, et al. Ultrafast capillary electrophoresis method for the simultaneous determination of ammonium and diphenhydramine in pharmaceutical samples. *Journal of separation science*. 2018.
69. Varcoe JR. Investigations of the ex situ ionic conductivities at 30 degrees C of metal-cation-free quaternary ammonium alkaline anion-exchange membranes in

- static atmospheres of different relative humidities. *Physical chemistry chemical physics : PCCP*. 2007;9(12):1479-86.
70. Wang K, Lei Y, Eitel M, Tan S. Ion chromatographic analysis of anions in ammonium hydroxide, hydrofluoric acid, and slurries, used in semiconductor processing. *Journal of chromatography A*. 2002;956(1-2):109-20.
  71. Xu X, Wang L, Wang J, Yin Q, Dong S, Han J, et al. Hydroxide-ion-conductive gas barrier films based on layered double hydroxide/polysulfone multilayers. *Chemical communications*. 2018;54(56):7778-81.
  72. Yokota N, Ono H, Miyake J, Nishino E, Asazawa K, Watanabe M, et al. Anion conductive aromatic block copolymers containing diphenyl ether or sulfide groups for application to alkaline fuel cells. *ACS applied materials & interfaces*. 2014;6(19):17044-52.
  73. Zarrin H, Fu J, Jiang G, Yoo S, Lenos J, Fowler M, et al. Quaternized graphene oxide nanocomposites as fast hydroxide conductors. *ACS nano*. 2015;9(2):2028-37.
  74. Berwig KH, Baldasso C, Dettmer A. Production and characterization of poly(3-hydroxybutyrate) generated by *Alcaligenes latus* using lactose and whey after acid protein precipitation process. *Bioresource technology*. 2016;218:31-7.
  75. Gao AH, Bule MV, Laskar DD, Chen S. Structural and thermal characterization of wheat straw pretreated with aqueous ammonia soaking. *Journal of agricultural and food chemistry*. 2012;60(35):8632-9.
  76. Halverson AW, Emerick RJ. Nitrogen distribution and acid production in corn silage treated with ammonium hydroxide. *Journal of agricultural and food chemistry*. 1982;30(3):474-7.
  77. Kramer-Haimovich H, Servi E, Katan T, Rollins J, Okon Y, Prusky D. Effect of ammonia production by *Colletotrichum gloeosporioides* on pelB activation, pectate lyase secretion, and fruit pathogenicity. *Applied and environmental microbiology*. 2006;72(2):1034-9.
  78. Nuernberg GB, Moreira MA, Ernani PR, Almeida JA, Maciel TM. Efficiency of basalt zeolite and Cuban zeolite to adsorb ammonia released from poultry litter. *Journal of environmental management*. 2016;183(Pt 3):667-72.
  79. Spesyvyi A, Smith D, Spanel P. Selected Ion Flow-Drift Tube Mass Spectrometry: Quantification of Volatile Compounds in Air and Breath. *Analytical chemistry*. 2015;87(24):12151-60.
  80. Zou T, Williams N, Ozkan SB, Ghosh K. Proteome folding kinetics is limited by protein half-life. *PloS one*. 2014;9(11):e112701.
  81. Morsa D, Gabelica V, De Pauw E. Effective temperature of ions in traveling wave ion mobility spectrometry. *Analytical chemistry*. 2011;83(14):5775-82.
  82. Rastogi S, Reuter N, Liberles DA. Evaluation of models for the evolution of protein sequences and functions under structural constraint. *Biophysical chemistry*. 2006;124(2):134-44.
  83. Stainier C, Destain MF, Schiffers B, Lebeau F. Effect of tank mixed adjuvants on the drift potential of phenmedipham formulations. *Communications in agricultural and applied biological sciences*. 2005;70(4):979-87.
  84. Chen JX, Zhang H, Li YQ. Drift of spiral waves controlled by a polarized electric field. *The Journal of chemical physics*. 2006;124(1):14505.
  85. Adams JL, Rancourt ED, Christensen AM. The Effect of Household Oxidizing Cleaners on Chemiluminescence of Blood Using Bluestar((R)). *Journal of forensic sciences*. 2018.
  86. Ling SL, Mc DTD, Robinson J. Workplace chemical and toxin exposures reported to a Poisons Information Centre: a diverse range causing variable morbidity. *European journal of emergency medicine : official journal of the European Society for Emergency Medicine*. 2018;25(2):134-9.

87. Richman KE, Butt CM, Young CJ. Size-resolved particle measurements of polybrominated diphenyl ethers indoors: Implications for sources and human exposure. *Environmental toxicology and chemistry*. 2018;37(2):481-90.
88. Wieck S, Olsson O, Kummerer K, Klaschka U. Fragrance allergens in household detergents. *Regulatory toxicology and pharmacology* : RTP. 2018;97:163-9.
89. Dhanda S, Gupta S, Halder A, Sunkaria A, Sandhir R. Systemic inflammation without gliosis mediates cognitive deficits through impaired BDNF expression in bile duct ligation model of hepatic encephalopathy. *Brain, behavior, and immunity*. 2018;70:214-32.
90. Ellersdorfer M. The ion-exchanger-loop-stripping process: ammonium recovery from sludge liquor using NaCl-treated clinoptilolite and simultaneous air stripping. *Water science and technology : a journal of the International Association on Water Pollution Research*. 2018;77(3-4):695-705.
91. Falahi H, Sharifi M, Ahmadian Chashmi N, Zare Maivan H. Water stress alleviation by polyamines and phenolic compounds in *Scrophularia striata* is mediated by NO and H₂O₂. *Plant physiology and biochemistry* : PPB. 2018;130:139-47.
92. Wood CM, Gonzalez RJ, Ferreira MS, Braz-Mota S, Val AL. The physiology of the Tambaqui (*Colossoma macropomum*) at pH 8.0. *Journal of comparative physiology B, Biochemical, systemic, and environmental physiology*. 2018;188(3):393-408.
93. Eller, Karsten; Henkes, Erhard; Rossbacher, Roland; Höke, Hartmut (2000). "Amines, Aliphatic". *Ullmann's Encyclopedia of Industrial Chemistry*. doi:10.1002/14356007.a02_001. ISBN 978-3-527-30673-2
94. Moss FR, 3rd, Shuken SR, Mercer JAM, Cohen CM, Weiss TM, Boxer SG, et al. Ladderane phospholipids form a densely packed membrane with normal hydrazine and anomalously low proton/hydroxide permeability. *Proceedings of the National Academy of Sciences of the United States of America*. 2018;115(37):9098-103.
95. Igalavithana AD, Yang X, Zahra HR, Tack FMG, Tsang DCW, Kwon EE, et al. Metal(loid) immobilization in soils with biochars pyrolyzed in N₂ and CO₂ environments. *The Science of the total environment*. 2018;630:1103-14.
96. Levi M, Hjelm C, Harari F, Vahter M. ICP-MS measurement of toxic and essential elements in human breast milk. A comparison of alkali dilution and acid digestion sample preparation methods. *Clinical biochemistry*. 2018;53:81-7.
97. Moreno-Gonzalez D, Haselberg R, Gamiz-Gracia L, Garcia-Campana AM, de Jong GJ, Somsen GW. Fully compatible and ultra-sensitive micellar electrokinetic chromatography-tandem mass spectrometry using sheathless porous-tip interfacing. *Journal of chromatography A*. 2017;1524:283-9.
98. Yu L, Yang J, Wang X, Jiang B, Sun Y, Ji Y. Antioxidant and antitumor activities of *Capparis spinosa* L. and the related mechanisms. *Oncology reports*. 2017;37(1):357-67.
99. Peeters K, Lespes G, Milacic R, Scancar J. Adsorption and degradation processes of tributyltin and trimethyltin in landfill leachates treated with iron nanoparticles. *Environmental research*. 2015;142:511-21.
100. Mori IC, Arias-Barreiro CR, Koutsaftis A, Ogo A, Kawano T, Yoshizuka K, et al. Toxicity of tetramethylammonium hydroxide to aquatic organisms and its synergistic action with potassium iodide. *Chemosphere*. 2015;120:299-304.
101. Sanandiya ND, Siddhanta AK. Chemical studies on the polysaccharides of *Salicornia brachiata*. *Carbohydrate polymers*. 2014;112:300-7.
102. Ortiz-Pujols S, Jones SW, Short KA, Morrell MR, Bermudez CA, Tilley SL, et al. Management and sequelae of a 41-year-old Jehovah's witness with severe

- anhydrous ammonia inhalation injury. *Journal of burn care & research : official publication of the American Burn Association*. 2014;35(3):e180-3.
103. Hendriks HS, Meijer M, Muilwijk M, van den Berg M, Westerink RH. A comparison of the in vitro cyto- and neurotoxicity of brominated and halogen-free flame retardants: prioritization in search for safe(r) alternatives. *Archives of toxicology*. 2014;88(4):857-69.
  104. Herrero Latorre C, Barciela Garcia J, Garcia Martin S, Pena Crecente RM. Solid phase extraction for the speciation and preconcentration of inorganic selenium in water samples: a review. *Analytica chimica acta*. 2013;804:37-49.
  105. Waaijers SL, Hartmann J, Soeter AM, Helmus R, Kools SA, de Voogt P, et al. Toxicity of new generation flame retardants to *Daphnia magna*. *The Science of the total environment*. 2013;463-464:1042-8.
  106. Kim SD, Choe WG, Jeong JR. Environmentally friendly electroless plating for Ag/TiO₂-coated core-shell magnetic particles using ultrasonic treatment. *Ultrasonics sonochemistry*. 2013;20(6):1456-62.
  107. Park SH, Park J, You KH, Shin HC, Kim HO. Tetramethylammonium hydroxide poisoning during a pallet cleaning demonstration. *Journal of occupational health*. 2013;55(2):120-4.
  108. Yang GD, Gao R, Wang Y, Li JC, Hu YC, Kang DJ, et al. Determination of swainsonine in the endophytic *Undifilum* fungi by high-performance liquid chromatography with evaporative light-scattering detector. *Toxicon : official journal of the International Society on Toxinology*. 2012;60(1):44-9.
  109. Hanai T. Quantitative In Silico Analysis of Retention of Phenylthiohydantoin-Amino Acids in Reversed-Phase Ion-Pair Liquid Chromatography. *Journal of chromatographic science*. 2016;54(4):604-8.
  110. D'Agostino C, Gladden LF, Mantle MD, Abbott AP, Ahmed EI, Al-Murshedi AY, et al. Molecular and ionic diffusion in aqueous - deep eutectic solvent mixtures: probing inter-molecular interactions using PFG NMR. *Physical chemistry chemical physics : PCCP*. 2015;17(23):15297-304.
  111. Lavkush Bhaisare M, Pandey S, Shahnawaz Khan M, Talib A, Wu HF. Fluorophotometric determination of critical micelle concentration (CMC) of ionic and non-ionic surfactants with carbon dots via Stokes shift. *Talanta*. 2015;132:572-8.
  112. Rodriguez-Sanchez S, Quintanilla-Lopez JE, Soria AC, Sanz ML. Evaluation of different hydrophilic stationary phases for the simultaneous determination of iminosugars and other low molecular weight carbohydrates in vegetable extracts by liquid chromatography tandem mass spectrometry. *Journal of chromatography A*. 2014;1372C:81-90.
  113. Lei B, Shin KH, Koh YH, Kim HE. Porous gelatin-siloxane hybrid scaffolds with biomimetic structure and properties for bone tissue regeneration. *Journal of biomedical materials research Part B, Applied biomaterials*. 2014;102(7):1528-36.
  114. Jha I, Attri P, Venkatesu P. Unexpected effects of the alteration of structure and stability of myoglobin and hemoglobin in ammonium-based ionic liquids. *Physical chemistry chemical physics : PCCP*. 2014;16(12):5514-26.
  115. Attri P, Baik KY, Venkatesu P, Kim IT, Choi EH. Influence of hydroxyl group position and temperature on thermophysical properties of tetraalkylammonium hydroxide ionic liquids with alcohols. *PloS one*. 2014;9(1):e86530.
  116. Narayanam M, Handa T, Sharma P, Hajar S, Muthe PK, Dappili PK, et al. Critical practical aspects in the application of liquid chromatography-mass spectrometric studies for the characterization of impurities and degradation products. *Journal of pharmaceutical and biomedical analysis*. 2014;87:191-217.
  117. Allen D, El Rassi Z. Capillary electrochromatography with monolithic silica column: I. Preparation of silica monoliths having surface-bound octadecyl moieties

- and their chromatographic characterization and applications to the separation of neutral and charged species. *Electrophoresis*. 2003;24(3):408-20.
118. Juszczak LJ, Eisenberg AS. The Color of Cation- π Interactions: Subtleties of Amine-Tryptophan Interaction Energetics Allow for Radical-like Visible Absorbance and Fluorescence. *Journal of the American Chemical Society*. 2017;139(24):8302-11.
  119. Kannamkumarath SS, Wrobel K, Wuilloud RG. Studying the distribution pattern of selenium in nut proteins with information obtained from SEC-UV-ICP-MS and CE-ICP-MS. *Talanta*. 2005;66(1):153-9.
  120. Li H, Aluko RE. Identification and inhibitory properties of multifunctional peptides from pea protein hydrolysate. *Journal of agricultural and food chemistry*. 2010;58(21):11471-6.
  121. Liu T, Li M, Guo L. Designing and facilely synthesizing a series of cobalt nitride (Co₄N) nanocatalysts as non-enzymatic glucose sensors: A comparative study toward the influences of material structures on electrocatalytic activities. *Talanta*. 2018;181:154-64.
  122. Majdan M, Pikus S, Gajowiak A, Sternik D, Zieba E. Uranium sorption on bentonite modified by octadecyltrimethylammonium bromide. *Journal of hazardous materials*. 2010;184(1-3):662-70.
  123. Quelemes PV, de Araujo AR, Placido A, Delerue-Matos C, Maciel JS, Bessa LJ, et al. Quaternized cashew gum: An anti-staphylococcal and biocompatible cationic polymer for biotechnological applications. *Carbohydrate polymers*. 2017;157:567-75.
  124. Tiritiris I, Kantlehner W. Crystal structure of N-[3-(di-methyl-aza-nium-yl)propyl]-N',N',N'',N'''-tetra-methyl-N-(N,N,N',N'-tetra-methyl-form-am-id-in-ium-yl)-guanidinium dibromide hydroxide monohydrate. *Acta crystallographica Section E, Crystallographic communications*. 2015;71(Pt 12):o1078-9.
  125. Zoffmann S, Chollet A, Galzi JL. Identification of the extracellular loop 2 as the point of interaction between the N terminus of the chemokine MIP-1 α and its CCR1 receptor. *Molecular pharmacology*. 2002;62(3):729-36.
  126. Balducci AG, Cagnani S, Sonvico F, Rossi A, Barata P, Colombo G, et al. Pure insulin highly respirable powders for inhalation. *European journal of pharmaceutical sciences : official journal of the European Federation for Pharmaceutical Sciences*. 2014;51:110-7.
  127. Das G, Kakati N, Lee SH, Karak N, Yoon YS. Water soluble sodium sulfate nanorods as a versatile template for the designing of copper sulfide nanotubes. *Journal of nanoscience and nanotechnology*. 2014;14(6):4455-61.
  128. Deshmukh R, Mehra A, Thaokar R. Formation and shape-control of hierarchical cobalt nanostructures using quaternary ammonium salts in aqueous media. *Beilstein journal of nanotechnology*. 2017;8:494-505.
  129. Patel RP, Narkowicz C, Jacobson GA. Effective reversed-phase ion pair high-performance liquid chromatography method for the separation and characterization of intact low-molecular-weight heparins. *Analytical biochemistry*. 2009;387(1):113-21.
  130. Abdi I, Al-Sadhan K, Ben Ali A. Crystal structure of bis-(propane-1,3-diaminium) hexa-fluorido-aluminate di-aqua-tetra-fluorido-aluminate tetra-hydrate. *Acta crystallographica Section E, Structure reports online*. 2014;70(Pt 12):471-3.
  131. Abdi I, Al-Sadhan KA, Ben Ali A. Crystal structure of bis-(propane-1,3-diammonium) hexa-fluorido-aluminate fluoride trihydrate. *Acta crystallographica Section E, Structure reports online*. 2014;70(Pt 9):m335-6.
  132. Attri P, Venkatesu P, Kumar A. Temperature effect on the molecular interactions between ammonium ionic liquids and N,N-dimethylformamide. *The journal of physical chemistry B*. 2010;114(42):13415-25.

133. Chen X, Shen J, Li T. PMMA microreactor for chemiluminescence detection of Cu (II) based on 1,10-Phenanthroline-hydrogen peroxide reaction. *Journal of food science and technology*. 2016;53(1):915-9.
134. Govinda V, Attri P, Venkatesu P, Venkateswarlu P. Evaluation of thermophysical properties of ionic liquids with polar solvent: a comparable study of two families of ionic liquids with various ions. *The journal of physical chemistry B*. 2013;117(41):12535-48.
135. Kumar PK, Rani A, Olasunkanmi LO, Bahadur I, Venkatesu P, Ebenso EE. Probing Molecular Interactions between Ammonium-Based Ionic Liquids and N,N-Dimethylacetamide: A Combined FTIR, DLS, and DFT Study. *The journal of physical chemistry B*. 2016;120(49):12584-95.
136. Chen P, Gershoni-Poranne R. Response to "Covalent Bonding and Charge Shift Bonds: Comment on "The Carbon-Nitrogen Bonds in Ammonium Compounds Are Charge Shift Bonds"". *Chemistry*. 2017;23(72):18325-9.
137. Frenking G. Covalent Bonding and Charge Shift Bonds: Comment on "The Carbon-Nitrogen Bonds in Ammonium Compounds Are Charge Shift Bonds". *Chemistry*. 2017;23(72):18320-4.
138. Guzman E, Mateos-Maroto A, Ruano M, Ortega F, Rubio RG. Layer-by-Layer polyelectrolyte assemblies for encapsulation and release of active compounds. *Advances in colloid and interface science*. 2017;249:290-307.
139. Ianchis R, Ninciuleanu CM, Gifu IC, Alexandrescu E, Somoghi R, Gabor AR, et al. Novel Hydrogel-Advanced Modified Clay Nanocomposites as Possible Vehicles for Drug Delivery and Controlled Release. *Nanomaterials*. 2017;7(12).
140. Kong D, Chen Z. Open-tubular capillary electrochromatography using carboxylatopillar[5]arene as stationary phase. *Electrophoresis*. 2018;39(2):363-9.
141. Li K, Fan Y, He Y, Zeng L, Han X, Yan Y. Burkholderia cepacia lipase immobilized on heterofunctional magnetic nanoparticles and its application in biodiesel synthesis. *Scientific reports*. 2017;7(1):16473.
142. Li Y, Wang Z, Wei Q, Luo M, Huang G, Sumer BD, et al. Non-covalent interactions in controlling pH-responsive behaviors of self-assembled nanosystems. *Polymer chemistry*. 2016;7(38):5949-56.
143. Rahman MS, Hossain SM, Rahman MT, Halim MA, Ishtiaq MN, Kabir M. Determination of trace metal concentration in compost, DAP, and TSP fertilizers by neutron activation analysis (NAA) and insights from density functional theory calculations. *Environmental monitoring and assessment*. 2017;189(12):618.
144. Sanchez-Milla M, Pastor I, Maly M, Serramia MJ, Gomez R, Sanchez-Nieves J, et al. Study of non-covalent interactions on dendriplex formation: Influence of hydrophobic, electrostatic and hydrogen bonds interactions. *Colloids and surfaces B, Biointerfaces*. 2018;162:380-8.
145. Szell PM, Gabidullin B, Bryce DL. 1,3,5-Tri(iodoethynyl)-2,4,6-trifluorobenzene: halogen-bonded frameworks and NMR spectroscopic analysis. *Acta crystallographica Section B, Structural science, crystal engineering and materials*. 2017;73(Pt 2):153-62.
146. Qin H, Xiao R, Zhang R, Chen J. Efficient adsorption of benzoic acid from aqueous solution by nitrogen-containing activated carbon. *Water science and technology : a journal of the International Association on Water Pollution Research*. 2018;2017(3):686-94.
147. Sanchez-Gonzalez J, Odoardi S, Bermejo AM, Bermejo-Barrera P, Romolo FS, Moreda-Pineiro A, et al. Development of a micro-solid-phase extraction molecularly imprinted polymer technique for synthetic cannabinoids assessment in urine followed by liquid chromatography-tandem mass spectrometry. *Journal of chromatography A*. 2018;1550:8-20.

148. Ito M, Alam MS, Suzuki M, Takahashi S, Komura M, Sangsriratakul N, et al. Virucidal activity of a quaternary ammonium compound associated with calcium hydroxide on avian influenza virus, Newcastle disease virus and infectious bursal disease virus. *The Journal of veterinary medical science*. 2018;80(4):574-7.
149. Monnin C, Ramrup P, Daigle-Young C, Vuckovic D. Improving negative liquid chromatography/electrospray ionization mass spectrometry lipidomic analysis of human plasma using acetic acid as a mobile-phase additive. *Rapid communications in mass spectrometry : RCM*. 2018;32(3):201-11.
150. Reinholds I, Pugajeva I, Zacs D, Lundanes E, Rusko J, Perkons I, et al. Determination of acidic non-steroidal anti-inflammatory drugs in aquatic samples by liquid chromatography-triple quadrupole mass spectrometry combined with carbon nanotubes-based solid-phase extraction. *Environmental monitoring and assessment*. 2017;189(11):568.
151. Sun Z, Lin B, Yan F. Anion-Exchange Membranes for Alkaline Fuel-Cell Applications: The Effects of Cations. *ChemSusChem*. 2018;11(1):58-70.
152. Thompson Brewster E, Jermakka J, Freguia S, Batstone DJ. Modelling recovery of ammonium from urine by electro-concentration in a 3-chamber cell. *Water research*. 2017;124:210-8.
153. Yue K, Li X, Schrobback K, Sheikhi A, Annabi N, Leijten J, et al. Structural analysis of photocrosslinkable methacryloyl-modified protein derivatives. *Biomaterials*. 2017;139:163-71.
154. Bartolic M, Vovk A, Suput D. Effects of NH₄Cl application and removal on astrocytes and endothelial cells. *Cellular & molecular biology letters*. 2016;21:13.
155. Huang J, Wang KS, Liang C. Oxidative degradation of tetramethylammonium hydroxide (TMAH) by UV/persulfate and associated acute toxicity assessment. *Journal of environmental science and health Part A, Toxic/hazardous substances & environmental engineering*. 2017;52(9):930-7.
156. Sun L, Zhou D, Wilson DM. A novel quantitative method for recovering precipitated uric acid in urine and analysis by LC-MS/MS. *Bioanalysis*. 2017;9(5):447-57.
157. Sanna A, Steel L, Maroto-Valer MM. Carbon dioxide sequestration using NaHSO₄ and NaOH: A dissolution and carbonation optimisation study. *Journal of environmental management*. 2017;189:84-97.
158. Zhu G, Sun L, Dovichi NJ. Simplified capillary isoelectric focusing with chemical mobilization for intact protein analysis. *Journal of separation science*. 2017;40(4):948-53.
159. Simanaviciute D, Klimaviciute R, Rutkaite R. Equilibrium adsorption of caffeic, chlorogenic and rosmarinic acids on cationic cross-linked starch with quaternary ammonium groups. *International journal of biological macromolecules*. 2017;95:788-95.
160. Abdelrasoul A, Doan H, Lohi A, Cheng CH. The effect of contaminated particle sphericity and size on membrane fouling in cross flow ultrafiltration. *Environmental technology*. 2018;39(2):203-20.
161. Zhuang Y, Liu P, Wang L, Luo J, Zhang C, Guo X, et al. Mitochondrial oxidative stress-induced hepatocyte apoptosis reflects increased molybdenum intake in caprine. *Biological trace element research*. 2016;170(1):106-14.
162. Gu X, Ali T, Chen R, Hu G, Zhuang Y, Luo J, et al. In vivo studies of molybdenum-induced apoptosis in kidney cells of caprine. *Biological trace element research*. 2015;165(1):51-8.
163. Oblak E, Adamski R, Lachowicz TM. pH-dependent influence of a quaternary ammonium salt and an aminoester on the yeast *Saccharomyces cerevisiae* ultrastructure. *Cellular & molecular biology letters*. 2003;8(1):105-10.

164. Sathyanarayanan R. Crystal growth technique for composite resin bonding. A SEM study. *Indian journal of dental research : official publication of Indian Society for Dental Research*. 1998;9(3):99-103.
165. Nichols BA, Chiappino ML, Dawson CR. Demonstration of the mucous layer of the tear film by electron microscopy. *Investigative ophthalmology & visual science*. 1985;26(4):464-73.
166. Ortiz-Montalvo DL, Hakkinen SA, Schwier AN, Lim YB, McNeill VF, Turpin BJ. Ammonium addition (and aerosol pH) has a dramatic impact on the volatility and yield of glyoxal secondary organic aerosol. *Environmental science & technology*. 2014;48(1):255-62.
167. Palacios A, De Gracia A, Haurie L, Cabeza LF, Fernandez AI, Barreneche C. Study of the Thermal Properties and the Fire Performance of Flame Retardant-Organic PCM in Bulk Form. *Materials*. 2018;11(1).
168. Zanonato PL, Di Bernardo P, Vallet V, Szabo Z, Grenthe I. Alkali-metal ion coordination in uranyl(VI) poly-peroxide complexes in solution. Part 1: the Li(+), Na(+) and K(+)-peroxide-hydroxide systems. *Dalton transactions*. 2015;44(4):1549-56.
169. Zheng C, Chu Y, Xu L, Lei W, Wang F, Xia M. Synthesis and theoretical studies on nitrogen-rich salts of bis[4-nitraminofurazanyl-3-azoxy]azofurazan (ADNAAF). *Journal of molecular modeling*. 2017;23(1):12.
170. Hackett JM, Lagali N, Merrett K, Edelhauser H, Sun Y, Gan L, et al. Biosynthetic corneal implants for replacement of pathologic corneal tissue: performance in a controlled rabbit alkali burn model. *Investigative ophthalmology & visual science*. 2011;52(2):651-7.
171. Yamaguchi T, Baxter JG, Maebashi N, Asano T. Oral phosphate binders: phosphate binding capacity of iron (III) hydroxide complexes containing saccharides and their effect on the urinary excretion of calcium and phosphate in rats. *Renal failure*. 1999;21(5):453-68.
172. Chen Y, Shi X, Han B, Qin H, Li Z, Lu Y, et al. The complete control for the nanosize of spherical MCM-41. *Journal of nanoscience and nanotechnology*. 2012;12(9):7239-49.
173. Szabo Z, Grenthe I. On the mechanism of oxygen exchange between uranyl(VI) oxygen and water in strongly alkaline solution as studied by (17)O NMR magnetization transfer. *Inorganic chemistry*. 2010;49(11):4928-33.
174. Gupta K, Watson AA, Baptista T, Scheer E, Chambers AL, Koehler C, et al. Architecture of TAF11/TAF13/TBP complex suggests novel regulation properties of general transcription factor TFIID. *eLife*. 2017;6.
175. Ionita S, Feroiu V, Geana D. Phase Equilibria of the Carbon Dioxide + 1-Decanol System at High Pressures. *Journal of chemical and engineering data*. 2013;58(11):3069-77.
176. Marty MT, Baldwin AJ, Marklund EG, Hochberg GK, Benesch JL, Robinson CV. Bayesian deconvolution of mass and ion mobility spectra: from binary interactions to polydisperse ensembles. *Analytical chemistry*. 2015;87(8):4370-6.
177. Ried JS, Jeff MJ, Chu AY, Bragg-Gresham JL, van Dongen J, Huffman JE, et al. A principal component meta-analysis on multiple anthropometric traits identifies novel loci for body shape. *Nature communications*. 2016;7:13357.
178. Stanton MV, Robinson JL, Kirkpatrick SM, Farzinkhou S, Avery EC, Rigdon J, et al. DIETFITS study (diet intervention examining the factors interacting with treatment success) - Study design and methods. *Contemporary clinical trials*. 2017;53:151-61.
179. Sieniutycz S, Berry RS. Variational theory for thermodynamics of thermal waves. *Physical review E, Statistical, nonlinear, and soft matter physics*. 2002;65(4 Pt 2A):046132.

180. Bailey JL, Critser PJ, Whittington C, Kuske JL, Yoder MC, Voytik-Harbin SL. Collagen oligomers modulate physical and biological properties of three-dimensional self-assembled matrices. *Biopolymers*. 2011;95(2):77-93.
181. Lee CY, Herant M, Heinrich V. Target-specific mechanics of phagocytosis: protrusive neutrophil response to zymosan differs from the uptake of antibody-tagged pathogens. *Journal of cell science*. 2011;124(Pt 7):1106-14.
182. Pinzi S, Leiva D, Arzamendi G, Gandia LM, Dorado MP. Multiple response optimization of vegetable oils fatty acid composition to improve biodiesel physical properties. *Bioresource technology*. 2011;102(15):7280-8.
183. Redgwell RJ, Curti D, Robin F, Donato L, Pineau N. Extrusion-induced changes to the chemical profile and viscosity generating properties of citrus fiber. *Journal of agricultural and food chemistry*. 2011;59(15):8272-9.
184. Yoshikawa HY, Rossetti FF, Kaufmann S, Kaindl T, Madsen J, Engel U, et al. Quantitative evaluation of mechanosensing of cells on dynamically tunable hydrogels. *Journal of the American Chemical Society*. 2011;133(5):1367-74.
185. Crowder TM, Rosati JA, Schroeter JD, Hickey AJ, Martonen TB. Fundamental effects of particle morphology on lung delivery: predictions of Stokes' law and the particular relevance to dry powder inhaler formulation and development. *Pharmaceutical research*. 2002;19(3):239-45.
186. Dukhin SS, Zimmermann R, Duval JF, Werner C. On the applicability of the Brinkman equation in soft surface electrokinetics. *Journal of colloid and interface science*. 2010;350(1):1-4.
187. Fernandez-Alonso F, Bermejo FJ, McLain SE, Turner JF, Molaison JJ, Herwig KW. Observation of fractional Stokes-Einstein behavior in the simplest hydrogen-bonded liquid. *Physical review letters*. 2007;98(7):077801.
188. Fischer MW, Stolze-Rybczynski JL, Davis DJ, Cui Y, Money NP. Solving the aerodynamics of fungal flight: how air viscosity slows spore motion. *Fungal biology*. 2010;114(11-12):943-8.
189. Mladenova BY, Chumakova NA, Pergushov VI, Kokorin AI, Grampp G, Kattnig DR. Rotational and translational diffusion of spin probes in room-temperature ionic liquids. *The journal of physical chemistry B*. 2012;116(40):12295-305.
190. Mladenova BY, Kattnig DR, Grampp G. Room-temperature ionic liquids discerned via nitroxyl spin probe dynamics. *The journal of physical chemistry B*. 2011;115(25):8183-98.
191. Pearson J, Nguyen TL, Colfen H, Mulvaney P. Sedimentation of C60 and C70: Testing the Limits of Stokes' Law. *The journal of physical chemistry letters*. 2018;9(21):6345-9.
192. Wang Z, Belovich JM. A simple apparatus for measuring cell settling velocity. *Biotechnology progress*. 2010;26(5):1361-6.
193. Khaikate O, Meesin J, Pohmakotr M, Reutrakul V, Leowanawat P, Soorukram D, et al. Sulfinates and thiocyanates triggered 6-endo cyclization of o-alkynylisocyanobenzenes. *Organic & biomolecular chemistry*. 2018.
194. Claraz A, Masson G. Asymmetric iodine catalysis-mediated enantioselective oxidative transformations. *Organic & biomolecular chemistry*. 2018;16(30):5386-402.
195. Whittamore JM, Hatch M. Oxalate transport by the mouse intestine in vitro is not affected by chronic challenges to systemic acid-base homeostasis. *Urolithiasis*. 2018.
196. Lister A, Bourgeois S, Imenez Silva PH, Rubio-Aliaga I, Marbet P, Walsh J, et al. NRF2 regulates the glutamine transporter Slc38a3 (SNAT3) in kidney in response to metabolic acidosis. *Scientific reports*. 2018;8(1):5629.
197. Pazos Perez F. Uric Acid Renal Lithiasis: New Concepts. *Contributions to nephrology*. 2018;192:116-24.

198. Pham PH, Sokeechand BSH, Garver KA, Jones G, Lumsden JS, Bols NC. Fish viruses stored in RNAlater can remain infectious and even be temporarily protected from inactivation by heat or by tissue homogenates. *Journal of virological methods*. 2018;253:31-7.
199. Petriz J, Bradford JA, Ward MD. No lyse no wash flow cytometry for maximizing minimal sample preparation. *Methods*. 2018;134-135:149-63.
200. Campbell C, Cornthwaite H, Watterson J. Oxidation of Selected Phenothiazine Drugs During Sample Preparation: Effects of Varying Extraction Conditions on the Extent of Oxidation. *Journal of analytical toxicology*. 2018;42(2):99-114.
201. Tesfaye T, Sithole B, Ramjugernath D, Ndlela L. Optimisation of surfactant decontamination and pre-treatment of waste chicken feathers by using response surface methodology. *Waste management*. 2018;72:371-88.
202. Lujan-Rhenals D, Morawicki R, Shi Z, Ricke SC. Quantification of nitrogen in the liquid fraction and in vitro assessment of lysine bioavailability in the solid fraction of soybean meal hydrolysates. *Journal of environmental science and health Part B, Pesticides, food contaminants, and agricultural wastes*. 2018;53(1):12-7.
203. Wang R, Schmidt JW, Harhay DM, Bosilevac JM, King DA, Arthur TM. Biofilm Formation, Antimicrobial Resistance, and Sanitizer Tolerance of *Salmonella enterica* Strains Isolated from Beef Trim. *Foodborne pathogens and disease*. 2017;14(12):687-95.
204. Hakimi AM, Lashgari N, Mahernia S, Ziarani GM, Amanlou M. Facile one-pot four-component synthesis of 3,4-dihydro-2-pyridone derivatives: novel urease inhibitor scaffold. *Research in pharmaceutical sciences*. 2017;12(5):353-63.
205. Powers W, Capelari M. PRODUCTION, MANAGEMENT AND THE ENVIRONMENT SYMPOSIUM: Measurement and mitigation of reactive nitrogen species from swine and poultry production. *Journal of animal science*. 2017;95(5):2236-40.
206. Duus K, Draborg AH, Guven E, Moreno YM, Jacobsen S, Nielsen CT, et al. A fluorescence sedimentation assay for dsDNA antibodies. *Scandinavian journal of clinical and laboratory investigation*. 2017;77(6):465-71.
207. Fankoua SO, Bitja Nyom AR, Bahanak DND, Bilong Bilong CF, Pariselle A. Influence of preservative and mounting media on the size and shape of monogenean sclerites. *Parasitology research*. 2017;116(8):2277-81.
208. Dhand C, Venkatesh M, Barathi VA, Harini S, Bairagi S, Goh Tze Leng E, et al. Bio-inspired crosslinking and matrix-drug interactions for advanced wound dressings with long-term antimicrobial activity. *Biomaterials*. 2017;138:153-68.
209. Li M, Zhang S, Shi A, Qi W, Liu Y. Determination of quetiapine in human plasma by LC-MS/MS and its application in a bioequivalence study. *Journal of chromatography B, Analytical technologies in the biomedical and life sciences*. 2017;1060:10-4.
210. Glushakova LG, Alto BW, Kim MS, Bradley A, Yaren O, Benner SA. Detection of chikungunya viral RNA in mosquito bodies on cationic (Q) paper based on innovations in synthetic biology. *Journal of virological methods*. 2017;246:104-11.
211. Garbieri TF, Brozoski DT, Dionisio TJ, Santos CF, Neves LT. Human DNA extraction from whole saliva that was fresh or stored for 3, 6 or 12 months using five different protocols. *Journal of applied oral science : revista FOB*. 2017;25(2):147-58.
212. Zainul R, Alif A, Aziz H, Arief S, Dradjad S, Munaf E. 2015. Design of photovoltaic cell with copper oxide electrode by using indoor lights. *RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES* 6:353-61

213. Mawardi M, Deyundha D, Zainul R. Characterization of PCC Cement by Addition of Napa Soil from Subdistrict Sarilamak 50 Kota District as Alternative Additional Material for Semen Padang. *Proc. IOP Conference Series: Materials Science and Engineering*, 2018, 335:012034: IOP Publishing
214. Anhar A, Sumarmin R, Zainul R. 2016. Measurement of Glycemic Index of West Sumatera Local Rice Genotypes for Healthy Food Selection.
215. Zainul R. 2015. Disain dan Modifikasi Kolektor dan Reflektor Cahaya pada Panel Sel Surya Al/Cu₂O-Gel Na₂SO₄.
216. Mawardi Anwar E, Kosela S, Wibowo W, Zainul R. 2015. Study of Pb (II) biosorption from aqueous solution using immobilized *Spirogyra subsalsa* biomass. *Journal of Chemical and Pharmaceutical Research* 7:715-22
217. Desy Kurniawati I, Harmiwati SS, Chaidir Z, Munaf E. Rahmiana Zein, Hermansyah Aziz, Rahadian Zainul. 2015. Biosorption of Pb (II) from Aqueous Solutions Using Column Method by Lengken (Euphoria logan lour) Seed and Shell. *Journal of Chemical and Pharmaceutical Research* 7:872-7
218. Zainul R, Alif A, Aziz H, Arief S, Darajat S. 2015. Modifikasi dan Karakteristik IV Sel Fotovoltaik Cu₂O/Cu-Gel Na₂SO₄ Melalui Iluminasi Lampu Neon. *EKSAKTA* 2:50
219. Yasthopi A. 2015. Photoelectrospitting water for hydrogen production using illumination of indoor lights. *Journal of Chemical and Pharmaceutical Research* 7:246-56
220. Horiza, H., Azhar, M. and Efendi, J. (2017) "EKSTRAKSI DAN KARAKTERISASI INULIN DARI UMBI DAHLIA (*Dahlia sp.L*) SEGAR DAN DISIMPAN", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(01), pp. 31-39. doi: <https://doi.org/10.24036/eksakta/vol18-iss01/14>.
221. Zainul, R. (2016, September 24). Determination of the half-life and the quantum yield of ZnO semiconductor photocatalyst in humic acid. <https://doi.org/10.31227/osf.io/e8a9x>
222. Febriani, S. S., Yolanda, T., Arianti, V. A., & Zainul, R. (2018, September 2). A Review Solid Stated : Principles and Methode. <https://doi.org/10.31227/osf.io/7us4x>
223. Liza, Y. M., Yasin, R. C., Maidani, S. S., & Zainul, R. (2018, September 29). SOL GEL : PRINCIPLE AND TECHNIQUE (A REVIEW). <https://doi.org/10.31227/osf.io/2cuh8>
224. Zainul, R. (2016, November 19). Effect of Temperature and Particle Motion against the ability of ZnO Semiconductor Photocatalyst in Humic Acid. <https://doi.org/10.31227/osf.io/wnygb>
225. Dinata, A. A., Rosyadi, A. M., Hamid, S., & Zainul, R. (2018, August 31). A Review CHEMICAL VAPOR DEPOSITION : PROCESS AND APPLICATION. <https://doi.org/10.31227/osf.io/yfeau>
226. Putri, D. F., Ritonga, H. M., Murdiati, V., & Zainul, R. (2018, August 31). A REVIEW WHAT IS HYDROTHERMAL ?. <https://doi.org/10.31227/osf.io/dm56c>
227. Awalliyah, A., Ikhwan, H., Nugiasari, V., & Zainul, R. (2018, August 31). A REVIEW PRINSIP DASAR MILLING DALAM SINTESIS MATERIAL. <https://doi.org/10.31227/osf.io/9xsqe>
228. Zainul, R. (2016, December 18). Design and Modification of Copper Oxide Electrodes for Improving Conversion Coefficient Indoors Lights (PV-Cell) Photocells. <https://doi.org/10.31227/osf.io/pgn84>
229. Candani, D., Ulfah, M., Noviana, W., & Zainul, R. (2018, September 1). A Review Pemanfaatan Teknologi Sonikasi. <https://doi.org/10.31227/osf.io/uxknv>

230. Zainul, R., Alif, A., Aziz, H., Arief, S., & s. (2015, October 22). Photoelectrospitting Water Mechanism at Carbon Electrode Surface using Indoor lights. <https://doi.org/10.31227/osf.io/vcxq8>
231. M., Yani, S. R., & Zainul, R. (2017, September 4). Aktivasi Tanah Napa dan Pengaruhnya Terhadap Adsorpsi Ion Timbal (II)/ Pb²⁺. <https://doi.org/10.31227/osf.io/ps523>
232. P, O. M., A, L. G., S, A. Y. M., & Zainul, R. (2018, September 1). A Review Grinding : Teknik dan Prinsip Dasar pada Pengolahan Material. <https://doi.org/10.31227/osf.io/trv4q>
233. Zainul, R., Alif, A., Aziz, H., Arief, S., & s. (2015, October 22). Photoelectrospitting Water Mechanism at Carbon Electrode Surface using Indoor lights. <https://doi.org/10.31227/osf.io/vcxq8>
234. H., Sanjaya, H., & Zainul, R. (2016, August 30). Synthesis and Electrical Properties of ZnO-ITO and Al-ITO thin Film by Spin Coating Technique Through Sol Gel Process. <https://doi.org/10.31227/osf.io/unrt4>
235. M., Sanjaya, H., & Zainul, R. (2015, December 30). Characterization of napa soil and adsorption of Pb (II) from aqueous solutions using on column method. <https://doi.org/10.31227/osf.io/t8fh9>
236. Zainul, R., Oktavia, B., Dewata, I., & efendi, j. (2017, February 4). Studi Dinamika Molekular dan Kinetika Reaksi pada Pembelahan Molekul Air untuk Produksi Gas Hidrogen. <https://doi.org/10.31227/osf.io/876s3>
237. chaidir, z., Fadjria, N., A., & Zainul, R. (2016, December 5). ISOLATION AND MOLECULAR IDENTIFICATION OF FRESHWATER MICROALGAE IN MANINJAU LAKE WEST SUMATERA. <https://doi.org/10.31227/osf.io/nbcuf>
238. chaidir, z., Zainul, R., Nurakhbari, D., & Salim, M. (2016, September 24). Optimization of Spirulina Platensis Culture for Antioxidant Production. <https://doi.org/10.17605/OSF.IO/FD6E4>
239. Iryani, I., Iswendy, I. and Katrina, I. T. (2017) “UJI AKTIVITAS ANTI DIABETES MELLITUS SENYAWA METABOLIT SEKUNDER FRAKSI AIR DARI BERAS KETAN HITAM (Oryza satival. Var glutinosa) PADA MENCIT PUTIH”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(01), pp. 54-60. doi: <https://doi.org/10.24036/eksakta/vol18-iss01/17>.
240. Suryelita, S., Etika, S. B. and Kurnia, N. S. (2017) “ISOLASI DAN KARAKTERISASI SENYAWA STEROID DARI DAUN CEMARA NATAL (Cupressus funebris Endl.)”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(01), pp. 86-94. doi: <https://doi.org/10.24036/eksakta/vol18-iss01/23>.
241. Zainul R, Nurakhbari D, Salim M. Optimization of Spirulina Platensis Culture for Antioxidant Production.
242. Iskandar, I., Horiza, H. and Fauzi, N. (2017) “EFEKTIVITAS BUBUK BIJI PEPAYA (Carica Papaya Linnaeus) SEBAGAI LARVASIDA ALAMI TERHADAP KEMATIAN LARVA AEDES AEGYPTY TAHUN 2015”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(01), pp. 12-18. doi: <https://doi.org/10.24036/eksakta/vol18-iss01/12>.
243. Ramli, R., Jonuarti, R. and Hartono, A. (2017) “ANALISIS STRUKTUR NANO DARI LAPISAN TIPIS COBALT FERRITE YANG DIPREPARASI DENGAN METODE SPUTTERING”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(01), pp. 46-53. doi: <https://doi.org/10.24036/eksakta/vol18-iss01/16>.
244. Zainul R, Alif A, Aziz H, Arief S. 2015. DISAIN GEOMETRI REAKTOR FOTOSOL CAHAYA RUANG. *Jurnal Riset Kimia* 8:131
245. Sanjaya, H. (2017) “DEGRADASI METHYLENE BLUE MENGGUNAKAN KATALIS ZnO-PEG DENGAN METODE FOTOSONOLISIS”, *EKSAKTA:*

- Berkala Ilmiah Bidang MIPA*, 18(02), pp. 21-29. doi: <https://doi.org/10.24036/eksakta/vol18-iss02/45>.
246. Ningsih, S. K. (2017) "SINTESIS DAN KARAKTERISASI NANOPARTIKEL ZnO DOPED Cu²⁺ MELALUI METODA SOL-GEL", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(02), pp. 39-51. doi: <https://doi.org/10.24036/eksakta/vol18-iss02/51>.
  247. Zainul R, Dewata I. 2015. Determination of pH-BOD-COD and degradation in batang arau watersheds at Padang city.
  248. Saiya, A. (2017) "ANALISIS RESIDU KLORPIRIFOS DALAM SAYURAN KUBIS DENGAN METODE HPLC DI BEBERAPA PASAR TRADISIONAL DI SULAWESI UTARA", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(02), pp. 77-85. doi: <https://doi.org/10.24036/eksakta/vol18-iss02/57>.
  249. Syafei, N. (2017) "ANALISA FENOMENA KOROSI PELAT PIPA BAJA KARBON API 5L-X65 DALAM LARUTAN 250 ML ASAM ASETAT DAN 4750 ML AQUADES PADA KONDISI GAS CO₂ DAN H₂S JENUH PADA SUHU RUANG", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(02), pp. 113-120. doi: <https://doi.org/10.24036/eksakta/vol18-iss02/63>.
  250. Tutuarima, T. (2017) "SIFAT FISIK DAN KIMIA MARMALADE JERUK KALAMANSI (Citrus microcarpa) : KAJIAN KONSENTRASI PEKTIN DAN SUKROSA Physical and Chemical Properties of Marmalade Citrus of Calamondin (Citrus microcarpa) : Study of Pectin and Sucrose Concentrations", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 18(02), pp. 164-172. doi: <https://doi.org/10.24036/eksakta/vol18-iss02/73>.
  251. Ruswandi, R. (2018) "Determination of Fructose Content resulted by Inulin Hydrolysis with DNS as Oxidizer", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(1), pp. 14-23. doi: <https://doi.org/10.24036/eksakta/vol19-iss1/102>.
  252. Sanjaya, H. (2018) "DEGRADASI METIL VIOLET MENGGUNAKAN KATALIS ZnO-TiO₂ SECARA FOTOSONOLISIS", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(1), pp. 91-99. doi: <https://doi.org/10.24036/eksakta/vol19-iss1/131>.
  253. Hidayani, T. (2018) "GRAFTING POLIPROPILENA DENGAN MALEAT ANHIDRIDA SEBAGAI PENGIKAT SILANG DENGAN INISIATOR BENZOIL PEROKSIDA", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(1), pp. 56-62. doi: <https://doi.org/10.24036/eksakta/vol19-iss1/127>.
  254. Prabowo, H. (2018) "PENYELIDIKAN KELAYAKAN KIMIA DAN PENYEBARAN CADANGAN PASIR BESI DAERAH TIKU KABUPATEN AGAM UNTUK BAHAN BAKU SEMEN PADA PT. SEMEN PADANG", *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(1), pp. 39-42. doi: <https://doi.org/10.24036/eksakta/vol19-iss1/121>.
  255. Zainul R, Oktavia B, Dewata I, Efendi J. Thermal and Surface Evaluation on The Process of Forming a Cu₂O/CuO Semiconductor Photocatalyst on a Thin Copper Plate. *Proc. IOP Conference Series: Materials Science and Engineering*, 2018, 335:012039: IOP Publishing
  256. Zainul, R. (2016, December 18). Design and Modification of Copper Oxide Electrodes for Improving Conversion Coefficient Indoors Lights (PV-Cell) Photocells. <https://doi.org/10.31227/osf.io/pgn84>
  257. Fatimah, P., Jumalia, R., Novianti, E. R., & Zainul, R. (2018, August 31). A REVIEW Teknik Blended : Prinsip dan Dasar-Dasar. <https://doi.org/10.31227/osf.io/tm2w4>
  258. Syafei, N. (2018) "Riset Material ANALISA FENOMENA KOROSI PELAT PIPA BAJA KARBON API 5L-X65 DALAM LARUTAN 7900 ML AIR LAUT DAN 100 ML AMONIAK PADA KONDISI GAS CO₂ DAN H₂S JENUH PADA

- SUHU RUANG.”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(1), pp. 7-13. doi: <https://doi.org/10.24036/eksakta/vol19-iss1/83>.
259. Parbuntari, H., Prestica, Y., Gunawan, R., Nurman, M. and Adella, F. (2018) “Preliminary Phytochemical Screening (Qualitative Analysis) of Cacao Leaves (*Theobroma cacao* L.)”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(2), pp. 40-45. doi: <https://doi.org/10.24036/eksakta/vol19-iss2/142>.
  260. Dinata, M. and Soehardi, F. (2018) “Factor Analysis of Physics Chemistry Waters that Affects Damage Safety Cliff on the Outskirts of River Siak”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(2), pp. 46-49. doi: <https://doi.org/10.24036/eksakta/vol19-iss2/143>.
  261. Sofyanita, S. and Octaria, Z. (2018) “Fenthion Compound Degradation in the Pesticide Bayleton 500 ec in Sonolysis, Ozonolysis and Sonozonolysis with Addition of TiO₂-anatase”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(2), pp. 70-79. doi: <https://doi.org/10.24036/eksakta/vol19-iss2/153>.
  262. Harahap, F. and Lubis, L. (2018) “Analysis of Heavy Metals Distribution in the River Town of Hamasaki’s Rod Padangsidempuan”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(2), pp. 50-56. doi: <https://doi.org/10.24036/eksakta/vol19-iss2/149>.
  263. Syafei, N., Hidayat, D., Emilliano, E. and Men, L. (2018) “Analysis Cracking Corrosion on Carbon Steel Pipes API 5L-X65 In Solution 7700 ml Aquades, 250 ml Acetic Acid and 50 ml Ammonia with Gas CO₂ and H₂S in Saturation Condition”, *EKSAKTA: Berkala Ilmiah Bidang MIPA*, 19(2), pp. 21-31. doi: <https://doi.org/10.24036/eksakta/vol19-iss2/138>.