Vanadium Pentaoksida (V_2O_5) : Termodinamika Molecular dan Interaksi Ion dalam Larutan

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Abstrak. Vanadium Pentaoksida merupakan senyawa dengan rumus V_2O_5 . Vanadium Pentaoksida berwarna kuning orange dan ketika membeku membentuk kristal seperti jarum. Vanadium pentaoksida bersifat amfoter yang dapat bereaksi dengan asam maupun basa. Vanadium pentaoksida berfungsi atau dapat digunakan sebagai bahan katalis dari suatu larutan. Kelarutan senyawa ini terjadinya interaksi dari masing-masing molekul merupakan suatu proses dalam melakukan percobaan. V_2O_5 mengandung karbon pada batu bara, minyak mentah dan pasir tar. Tujuan dari review ini adalah untuk mengetahui karakteristik molecular secara termodinamika dan transfer ion dalam larutan. Metode yang digunakan adalah pemodelan komputasi di ChemOffice 15.0 yaitu Chem Draw Ultra 2D dan Chem Draw Bio 3D, dimana terlihat adanya pergerakan ion pada molekul. Data simulasi yang diperoleh dari referensi dalam pemodelan model vanadium pentaoksida, serta data dari hasil review beberapa jurnal penelitian yang berkaitan dengan senyawa vanadium pentaoksida. Hasil dari vanadium pentaoksida dilihat interaksinya dengan menentukan konduktivitas didapatkan $0,059 \times 10^8$ mho/cm, viskositas sebesar $0,579$ mPa.s, daya hanyut sebesar $1,508$ eV/cm, dan transfer ionic pada larutannya. Sifat termodinamikanya yaitu $\Delta S^\circ = 131$ J/mol K, $\Delta_f^\circ H = -1550,6$ KJ/mol, $\Delta_f^\circ G = -1419,5$ KJ/mol, $C_p = 127,7$ J/mol K. Senyawa ini dapat direaksikan dengan senyawa asam berlebih. Vanadium pentaoksida dapat bereaksi dalam air membentuk senyawa ion.

Keyword: Tranfer Ionik, konduktivitas, viskositas teori termodinamika, pemodelan MM2.

1. Pendahuluan

Vanadium(18; 19) pentaoksida dengan rumus kimianya V_2O_5 . Vanadium pentaoksida berbentuk padatan berwarna kuning orange. Senyawa ini dapat larut di dalam air dan dapat bersifat sebagai katalis dalam larutan.

Vanadium pentaoksida dapat dihasilkan dari beberapa reaksi asam, biasanya asam berlebih. Keistimewaan dari senyawa ini dapat bersifat asam maupun basa, atau disebut juga dengan amfoter. Massa molar dari vanadium pentaoksida 181.9 gram/mol. Titik lelehnya 690 °C dan titik didihnya 1750 °C.

Vanadium pentaoksida pergerakannya di dalam larutan cukup reaktif, karena adanya unsur(21-25) asam yang berlebih. Ketika dicampurkan di dalam senyawa lain, vanadium pentaoksida ini akan membentuk senyawa asam(26) bersama dengan larutannya.

Vanadium pentaoksida adalah logam yang dapat bereaksi secara langsung membentuk gas halogen yang sangat elektronegatif membentuk senyawa ionic. Jika dilarutkan di dalam air, vanadium pentaoksida berfungsi sebagai katalis dan jika direaksikan dengan asam berlebih dengan cara dilakukan dengan proses pemansan

Biasanya vanadium pentaoksida disintesis(27) dari katalis bekas yang diperoleh dari industri asam. Pengolahannya dilakukan dengan persiapan bahan(28) baku, sebelum emengolah vanadium

pentaoksida, dilakukan terlebih dahulu analisis V_2O_5 dengan menggunakan metode(29) Atomic Absorption Spectrophotometer (AAS).

Langkah pertama adalah memilih pelarut dengan volume tertentu dan dimasukkan ke dalam labu tiga leher, selanjutnya katalis dengan berat tertentu ditambahkan dengan sambil diaduk. Kemudian disaring, bagian padatnya dicuci dan hasil pencucian dievaporasi. Lau, di furnace selama 12 jam dan dianalisis kadar dari vanadium pentaoksida.

Vanadium pentaoksida dimasukkan dalam katalis bekas dimana keduanya dimasukkan ke dalam ammonia hidroksida(30). Sehingga bereaksi dan menghasilkan ammonium metavanadat. Selanjutnya dilakukan pemanasan dengan suhu $450\text{ }^{\circ}\text{C}$, maka akan terdekomposisi menjadi vanadium pentaoksida murni dengan menghasilkan warna kuning orange.

2. Metode

Metode(31) yang digunakan adalah komputasi dengan perhitungan matematika dan kimia. Proses(32) ini bertujuan untuk mengetahui dan memahami struktur dan karakteristik(33) dari vanadium pentaoksida menggunakan data yang diperoleh dari aplikasi Chem Draw Profesional 15.0 dan Chem Draw 3D serta melalui data-data yang diperoleh dari jurnal dan referensi lainnya.

Pemodelan dari molekul vanadium pentaoksida dibuat melalui Chem Draw Ultra 2D, selanjutnya di pindahkan ke Chem Draw Bio 3D. Menghasilkan model yang jelas dengan adanya pergerakan pada molekul air(34) pada vanadium pentaoksida.

Sifat fisika dan kimia dari senyawa ini di dapat dari Wikipedia. V_2O_5 bewarna kuning orange dan berbentuk padatan(35) yang dapat larut dalam air bersifat dapat menghantarkan arus listrik. Senyawa ini pada umumnya digunakan sebagai katalis dan pembuatan dalam bahan

3. Analisis Gap

Kegunaan vanadium pentaoksida adalah sebagai bahan pembuatan keramik dan sebagai katalis pada larutan. Sehingga vanadium pentaoksida ini sangat diperlukan bagi masa sekarang. Seperti pada lantai rumah dan vas bunga hiasan lainnya. Vanadium pentaoksida mudah ditemukan pada kehidupan sekarang, sehingga dalam proses pembuatan keramik sangat diperlukan senyawa ini.

Namun, dalam zaman sekarang masih banyak yang belum menggunakan bahan keramik untuk keperluan rumah tangga, dikarenakan kebutuhan ekonomi yang kurang memadai. Vanadium pentaoksida ini dalam waktu pengambilan sampelnya semakin lama akan semakin kecil seiring dengan kadar pengambilan dari sampel tersebut.

4. Hasil dan Pembahasan

1. Result

Senyawa	adalah V_2O_5
Penampilan	adalah padat kuning
Massa molar	adalah 181.8800 g/mol
Densitas	adalah 3.357 g/cm^3
Titik lebur	adalah $690\text{ }^{\circ}\text{C}$ ($1;274\text{ }^{\circ}\text{F}$; 963 K)
Titik Didih	adalah $1;750\text{ }^{\circ}\text{C}$ ($3;180\text{ }^{\circ}\text{F}$; $2;020\text{ K}$) (decomposes)
Kelarutan	adalah 0.8 g/L ($20\text{ }^{\circ}\text{C}$)
Struktur Kristal	adalah Ortorombik
Konstanta kisi	adalah $a = 1151\text{ pm}$, $b = 355.9\text{ pm}$, $c = 437.1\text{ pm}$
Geometri Koordinasi	adalah trigonal bipiramida terdistorsi (V)

a. Atom Penyusun Vanadium Pentaoksida

1.) Vanadium (V)

Vanadium adalah logam berwarna putih keabu-abuan yang lembut dan mulus. Vanadium memiliki daya tahan yang baik terhadap alkali, asam sulfur dan asam hidroklorik(36-38). Vanadium biasanya teroksidasi pada suhu 933 K. Vanadium mempunyai struktur yang baik (35), sehingga berguna dalam materi nuclear. Namun vanadium bisa dikatakan sejenis logam(39; 40), vanadium, kromin dan mangan memiliki ciri-ciri oksida valensi bersifat asam.

Vanadium terbentuk secara alami dimana terdiri dari satu isotop stabil ^{51}V , dan satu isotop(41; 42) radioaktif, ^{50}V . Vanadium memiliki waktu paruh $1,5 \times 10^{17}$ tahun dan kelimpahan alaminya 0,25 %. ^{51}V memiliki putaran nuklir 7/2. 24 radioisotop buatan lebih dikarakterisasi. Isotop yang paling stabil

adalah ^{49}V dengan waktu paruh 330 hari, dan ^{48}V memiliki waktu paruh 16,0 hari. Waktu paruh pada isotop radioaktif merupakan lebih pendek dari ssatu jam, biasanya berkisar di bawah 10 menit.

Isotop yang lebih ringan dari ^{51}V ditangkap oleh elektron(28). Ukuran yang paling umum ialah beta merupakan untuk yang lebih berat. Penangkapan electron berpusat pada pembentukan isotop elemen 22 (titanium), sedangkan yang menyebabkan isotop adalah terjadinya peluruhan.

Gambar 1. Bentuk Atom dari Penggabungan senyawa vanadium

<https://id.wikipedia.org/wiki/Vanadium>

Dalam suatu larutan berisi air, vanadium dapat membentuk senyawa oxyanion(31). Hubungan tersebut dapat dijelaskann dalam diagram predominan, menunjukkan 11 spesies yang tergantung pada pH dan konsentrasinya. Ion orthovanadate tetrahedral (VO_4^{3-}) berada pada PH 12-14 yang merupakan spesies utama.

Diagram (43-46) pourbaix di atas menunjukkan vanadium dalam larutan berair yang menunjukkan adanya redoks (23; 47-50) antara berbagai spesies di tempat oksidasi yang berbeda, juga kompleks pada vanadium.

2.) Oksigen (O)

Oksigen merupakan golongan kalkogen yang dapat dengan mudah hampir bereaksi kesemua unsur laninnya (utamanya menjadi oksida). Pada tekanan standar dan temperatur(51)nya, dua atom unsur (52) berikatan menjadi dioksigen yaitu senyawa gas diatomic dengan rumus O_2 yang tidak berwarna, tidak berasa dan tidak berbau.

Tabel 1. Isotop pada Oksigen Stabil

Isotop oksigen terstabil

Isotop	Kelimpahan	Waktu paruh($t_{1/2}$)	Moda peluruhan	Produk
^{16}O	99.76%	^{16}O	stabil dengan 8 neutron	
^{17}O	0.039%	^{17}O	stabil dengan 9 neutron	
^{18}O	0.201%	^{18}O	stabil dengan 10 neutron	

Gas diatomik (53-56) dapat mengisi 20,9 % volume atmosfer bumi. Oksigen memiliki orde ikatan (57-60) dua dan dijelaskan sebagai ikatan ganda ataupun sebagai kombinasi satu ikatan dua electron dengan dua ikatan dua electron serta dengan dua ikatan tiga electron.

Oksigen lebih suka larut dalam air dari pada nitrogen. Air mengandung sekitar satu molekul O_2 untuk setiap dua molekul N_2 , dibandingkan dengan rasio(61-63) atmosfer sekitar 1:4. Di dalam air, kelarutan (64-68) oksigen bergantung pada suhu 0°C , oksigen dalam air yaitu $14,6 \text{ mg}\cdot\text{L}^{-1}$. Pada suhu 25°C dan 1 atm udara, di dalam air tawar mengandung yaitu 6,04 mL oksigen perliter, dalam air laut mengandung yaitu,95 mL per liter.

Oksigen yang dapat ditemukan secara alami yaitu ^{16}O , ^{17}O , ^{18}O , dengan ^{16}O adalah unsur paling melimpah (99,762%). Isotop oksigen berkisar dari bernomor massa(69-72) 12 sampai dengan 28. ^{16}O disintesis pada prosess akhir fusi (73-77) helium terhadap bintang. Namun ada beberapa yang dapat dihasilkan pada proses pembakaran neon. ^{17}O dapat dihasilkan dari prosses pembakaran hydrogen menjadi helium yang terdapat dalam siklus CNO, sehingga menjadikan isotop yang paling umum pada pembakaran hydrogen (73-77) bintang tersebut. Kebanyakan ^{18}O didapatkan ketika ^{14}N (beerrasal dari pembakaran CNO) menangkap inti pada He.

Empat belas radioisotope (78-83) pada oksidgen ini telah berhasil pada karakterisasi, yang paling stabil ^{15}O memiliki waktu paruh 12,24 detik dan ^{14}O memiliki waktu paruh 70,606 detik. Sisa dari isotop radioaktif memiliki waktu paruh lebih pendek dari 27 detik, kebanyakan memiliki waktu paruh kurang dari 83 milidetik.

Karakteristik Senyawa V_2O_5

Gambar 2. Senyawa vanadium pentaoksida

Vanadium Pentaoksida tersusun dari unsur vanadium (V) dan Oksigen (O). Rumus molekul(84-87) senyawa ini adalah V_2O_5 . Massa molar (88-92) vanadium pentaoksida adalah 181.9 gram/mol. Titik lelehnya 690°C dan titik didihnya 1750°C . Vanadium pentaoksida Bewarna kuning orange dan ketika memb eku membentuk Kristal-kristal seperti jarum.

Berdasarkan rasio jari-jari (88-92) relative terhadap oksigen (-2), ukuran vanadium (+5) terlalu besar untuk koordinasi struktur tetrahedron, tetapi terlalu kecil untuk koordinasi octahedron. Oleh karena itu, vanadium pentaoksida memiliki struktur trigonal bipiramida terdistorsi.

Vanadium pentaoksida dapat diperoleh dari pemanasan vanadat (NH_4VO_3) dengan persamaan reaksi (93-98) sebagai berikut:

Selain itu, V_2O_5 dapat juga diperoleh melalui penambahan larutan asam(61; 99; 100) encer berlebih ke dalam larutan ammonium vanadate menurut persamaan reaksi sebagai berikut:

2. Data Molekul

Gambar 3. Pemodelan Molekul Vanadium Pentaoksida

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

Note: 1,3 van der Waals interactions are used to compute the energy of angles around atoms with more than 4 coordinate bonds.

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

Iteration	1	Steric Energy	5617.161	RMS Gradient	2030.278	RMS Move	0.0000
Iteration	2	Steric Energy	1915.189	RMS Gradient	761.850	RMS Move	0.0369
Iteration	3	Steric Energy	1876.021	RMS Gradient	775.998	RMS Move	0.0207
Iteration	4	Steric Energy	643.999	RMS Gradient	106.630	RMS Move	0.0449
Iteration	5	Steric Energy	527.862	RMS Gradient	132.338	RMS Move	0.0577
Iteration	6	Steric Energy	380.281	RMS Gradient	56.301	RMS Move	0.0468
Iteration	7	Steric Energy	329.225	RMS Gradient	41.062	RMS Move	0.0275
Iteration	8	Steric Energy	291.828	RMS Gradient	30.792	RMS Move	0.0246
Iteration	9	Steric Energy	265.143	RMS Gradient	26.066	RMS Move	0.0213
Iteration	10	Steric Energy	233.410	RMS Gradient	55.298	RMS Move	0.0573
Iteration	11	Steric Energy	212.370	RMS Gradient	30.930	RMS Move	0.0304
Iteration	12	Steric Energy	204.786	RMS Gradient	18.642	RMS Move	0.0136

Iteration 12: Minimization terminated normally because the gradient norm is less than the minimum gradient norm

Stretch:	45.6523
Bend:	113.5297
Stretch-Bend:	11.2891
Torsion:	0.0000
Non-1,4 VDW:	7.0824
1,4 VDW:	15.4922
Dipole/Dipole:	11.7402
Total Energy:	204.7859 kcal/mol
Calculation ended	

3. Bentuk Molekul

Gambar 4. Struktur Vanadium pentaoksida 3D

Gambar 5. Pemodelan Struktur Permukaan Translucen

Gambar 6. Pemodelan Struktur Wire Mash

Gambar 7. Analisis 3D pada molekul V_2O_5 setelah menggunakan optimasi MM2. Terlihat adanya molekul yang berwarna merah muda, menunjukkan adanya interaksi(30)

- a. **Optimasi Molekul V_2O_5 menggunakan Chem Draw Ultra 2D**
Vanadium Pentaoksida dapat dilihat pad Chem Draw ultra 2D

Gambar 8. Vanadium Pentaoksida pada Chem Drwa Ultra 2D

b. Optimasi Molekul V_2O_5 menggunakan Chem Draw Ultra 2D ke Chem Draw bio 3D

Optimasi Molekul V_2O_5 menggunakan Molecular Mechanic (MM2)

Optimasi molekul V_2O_5 dilakukan dengan Molekular(101) Mekanik (MM2) dan menghasilkan output data dalam bentuk data geometri atom-atom dalam molekul dan Energi optimumnya. Hasil output yang dioleh dapat dilihat sebagai berikut :

1. Optimasi MM2 Minimization
2. Optimasi MM2 Dynamics
3. Optimasi MM2 Properties(102)

Output MM2 Minimization, Dynamics dan Properties

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

Note: 1,3 van der Waals interactions are used to compute the energy of angles around atoms with more than 4 coordinate bonds.

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

Iteration 1 Steric Energy 204.786 RMS Gradient 18.642 RMS Move 0.0000

Iteration 2 Steric Energy 202.110 RMS Gradient 13.745 RMS Move 0.0048

Iteration 2: Minimization terminated normally because the gradient norm is less than the minimum gradient norm

Stretch: 44.7447

Bend: 111.6210

Stretch-Bend: 11.2290

Torsion: 0.0000

Non-1,4 VDW: 7.3634

1,4 VDW: 15.3027

Dipole/Dipole: 11.8496

Total Energy: 202.1104 kcal/mol

Calculation ended

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

Note: 1,3 van der Waals interactions are used to compute the energy of angles around atoms with more than 4 coordinate bonds.

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

Iteration Time Total Energy Potential Energy Temperature

1	0.002	202.033 ± 0.000	198.524 ± 0.000	47.08 ± 0.00
2	0.004	201.780 ± 0.000	191.141 ± 0.000	142.76 ± 0.00
3	0.006	201.746 ± 0.000	184.203 ± 0.000	235.42 ± 0.00
4	0.008	201.943 ± 0.000	178.467 ± 0.000	315.04 ± 0.00
5	0.010	202.183 ± 0.000	173.488 ± 0.000	385.07 ± 0.00
6	0.012	202.161 ± 0.000	167.515 ± 0.000	464.93 ± 0.00
7	0.014	201.932 ± 0.000	162.243 ± 0.000	532.60 ± 0.00
8	0.016	201.928 ± 0.000	158.957 ± 0.000	576.64 ± 0.00
9	0.018	201.922 ± 0.000	156.753 ± 0.000	606.14 ± 0.00
10	0.020	202.043 ± 0.000	155.146 ± 0.000	629.32 ± 0.00
11	0.022	202.007 ± 0.000	153.890 ± 0.000	645.70 ± 0.00

12	0.024	201.757 ± 0.000	152.636 ± 0.000	659.17 ± 0.00
13	0.026	201.766 ± 0.000	149.980 ± 0.000	694.94 ± 0.00
14	0.028	201.896 ± 0.000	146.137 ± 0.000	748.24 ± 0.00
15	0.030	201.925 ± 0.000	141.862 ± 0.000	806.01 ± 0.00
16	0.032	201.641 ± 0.000	139.922 ± 0.000	828.22 ± 0.00
17	0.034	201.678 ± 0.000	141.011 ± 0.000	814.11 ± 0.00
18	0.036	201.986 ± 0.000	143.724 ± 0.000	781.84 ± 0.00
19	0.038	201.936 ± 0.000	145.640 ± 0.000	755.45 ± 0.00
20	0.040	201.698 ± 0.000	145.249 ± 0.000	757.51 ± 0.00

Calculation ended

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

Note: 1,3 van der Waals interactions are used to compute the energy of angles around atoms with more than 4 coordinate bonds.

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

Stretch:	11.4378
Bend:	98.4905
Stretch-Bend:	-1.6376
Torsion:	0.0000
Non-1,4 VDW:	4.7072
1,4 VDW:	15.2570
Dipole/Dipole:	16.9937
Total Energy:	145.2486 kcal/mol

The total energy for this frame: 145.249 kcal/mol

Calculation ended

4. Jari-jari Atom

MM2	Constant	Value	Quality
Cubic	stretch constant	-2.000	4
Quartic	stretch constant	2.333	4
Sextic	bending constant	(* 10**8)7.000	4
Cutoff	charge interactions	35.000	4
Cutoff	dipole interactions	25.000	4
Cutoff	dipole interactions	18.000	4
Cutoff	distance for van der Waals interactions	10.000	4

MM2 c3dAtom	Radius	Eps	Weight	Reduct	Lone Pairs	Quality
236	2.847	0.200	50.944	0.000	0	1

5. Jari-jari Molekul

Gambar 9. Pemodelan vanadium Pentaoksida dengan memperlihatkan jjar-ari antar atomnya

MM2	Constant	Value	Quality
Cubic	stretch constant	-2.000	4
Quartic	stretch constant	2.333	4
X-B,C,N,O-Y	Stretch-Bend interaction force constant	0.120	4
X-Ga,Ge,As,Se,Br-Y	Stretch-Bend force constant	0.250	3
Sextic	bending constant (* 10**8)	7.000	4
Dielectric	constant for dipoles	1.500	4
Cutoff distance for charge/charge interactions	35.000	4	
Cutoff distance for charge/dipole interactions	25.000	4	
Cutoff distance for dipole/dipole interactions	18.000	4	
Cutoff distance for van der Waals interactions	10.000	4	

MM2	c3dAtomRadius	Eps	Weight	Reduct	Lone Pairs	Quality
236	2.847	0.200	50.944	0.000	0	1
6	1.740	0.050	15.995	0.000	2	4
5	1.500	0.047	1.008	0.915	0	4

Bond	KS	Bond Length	Dipole	Quality
6-6	3.950	1.428	0.000	3
6-20	4.600	0.600	0.900	4

Angle	KB	XR2	XRH	XH2	Quality
20-6-20	0.240	131.0	0.0	0.0	4
6-6-20	0.350	103.3	0.0	0.0	3

Torsional	V1	V2	V3	Quality
0-0-0-0	0.000	0.000	0.000	1
20-6-6-20	0.000	0.000	0.000	3

6. Sifat-sifat Termodinamika

$$\Delta^{\circ}S = 131 \text{ J/mol.K}$$

$$\Delta_f^{\circ}H = -1550,6 \text{ Kj/mol.}$$

$$\Delta_f^{\circ}G = -1419,5 \text{ Kj/mol.}$$

$$C_p = 127,7 \text{ J/mol.K}$$

7. Gerak Molekul

Transfer Ionik Dalam Larutan

Dikatakan transfer ion karena pada vanadium pentaoksida mengandung ikatan semilogam(51) dengan nonlogam, sehingga jika dilarutkan ke dalam air akan membentuk ikatan ionic. Disini yang bersifat sebagai asam adalah Vanadium dan bertindak sebagai basa(103) adalah Oksigennya.

Sifat-sifat dari vanadium pentaoksida adalah logam yang berikatan ionic di dalam air(104), karena mengandung unsur asam dan memiliki kekuatan struktur (105-110) yang baik, serta memiliki kemampuan neutron fisi yang rendah. Vanadium pentaoksida jika dilarutkan ke dalam air dapat berfungsi sebagai katalis jika direaksikan dengan asam dan lebih baik dilakukan dalam waktu pemansan.

Ketika dalam bentuk padatan, vanadium pentaoksida bersifat dapat menghantarkan arus listrik. Sehingga ketika dilelehkan atau larut, maka akan mejadi sangat kondusif karena mobilisasi ion-ionnya. Menurut teori HSAB, senyawa dengan karakter ionic (111-116) adalah yang terdiri dari asam kuat(85; 117; 118) dan basa kuat, ion kecil bermuatan sangat tinggi dengan perbedaan keelektronegatifan yang tinggi antara anion dan kation.

Perbedaan dalam keelektronegatifan ini berarti dalam pemisahan muatan dan momem dipol(119-121) yang dihasilkan akan dipertahankan bahkan ketika ion-io terseut bersentuhan (electron berlebih pada anion tidak ditransfer maupun terpolarisasi untuk menetralkan kation).

Pergerakan vanadium pentaoksida di dalam larutan cukup reaktif, karena adanya unsur asam yang berlebih, sehingga ketika dicampurkan dengan senyawa lain akan membentuk senyawa asam (122-128) berlebih dan tergantung dari senyawa yang dicampurkan, serta dapat memberikan ikatan ionic(129-131) berupa anion dan kation dalam larutan.

8. Viskositas

Tingkat kekentalan atau viskositas larutan vanadium pentaoksida dalam berbagai temperature.

Tabel 2. Pengaruh temperature terhadap Viskositas

Temperatur °C	Viskositas(mPa·s)
654	1,12
765	0,95
824	0,84

Perhitungan Viskositas

Diketahui :

Radius of $V^{+5} = 205 \text{ pm}$

Radius of $Br^- = 152 \text{ pm}$

Radius Ratio = $205/152 = 1,358n$

$\rho_{air} = 1,00 \text{ (25°C, g/cm}^3\text{)}$

$\rho_{V^2O^5} = 3,36 \text{ (25°C, g/cm}^3\text{)}$

$v = 1670 \text{ m/s}$

Ditanya : viskositas

Dijawab :

$$\eta = \frac{2r^2g}{9v} (\rho_{V^2O^5} - \rho_{air})$$

$$\eta = \frac{2(1,358)^2 10 \text{ kg/m}^3}{9.1670 \text{ m/s}} (3360 - 1000) \text{ kg/m}^3$$

$$\eta = \frac{3,6883 \text{ kg/m}^3}{15030 \text{ m/s}} 2360 \text{ kg/m}^3$$

$$\eta = 0,579 \text{ mPa.s}$$

9. Daya Hanyut

Kecepatan daya hanyut berdasrkan laju reaksi(132) transportasi dari ion, maka dihasilkan adanya efektifitas(133) dari konduktifitasnya berkurang dengan bertambahnya viskositas pelarut ukuran ion.

Perhitungan kecepatan hanyut : $E = \frac{\Delta\phi}{l}$

vertical potential 7,54 eV

$$E = \frac{7,54 \text{ eV}}{5 \text{ cm}} = 1,508 \text{ eV/cm}$$

10. Hantaran

Konduktifitas Padatan Ionik

Konduktifitas(131; 134; 135) disebut juga dengan hantaran listrik(87; 136-138) padatan ionic. Biasanya ikatannya lemah dikarenakan sulitnya ion-ion mengalami migrasi(87; 139; 140) dari satu posisi ke posisi yang lain karena ion-ion tersebut cenderung terikat secara kuat dalam kisi kristalnya(137; 138; 141-143).

Logam(144-146) seperti vanadium ini dapat bereaksi secara langsung dengan gas halogen(147-149) yang sangat elektronegatif membentuk ionic. Disini Vanadium bereaksi dengan oksigen, jika senyawa tersebut larut dalam pelarut, senyawa ini dapat diperoleh dengan senyawa padat dan menguapkan larutannya dari larutan elektrolit(150) (151-153) ini.

Ketika pelarut diuapkan, ion tidak ikut menguap, tetapi tetap berada di dalam larutan yang tertinggal, dan bila sudah cukup pekat terjadilah nukleasi(154-156) dan mengkristal menjadi senyawa ionic. Proses ini dapat dinamakan dengan cara pembentukan mineral evaporit (157-162). Pada vanadium pentaoksida memiliki titik lebur(163-166) yang tinggi yaitu 1910 °C karena itulah dapat menghantarkan arus listrik (167-172) dengan baik, walaupun konduktifitasnya yang rendah.

Contoh:

No	Variabel	Konsentrasi V_2O_5	Konduktifitas V_2O_5
11.	X_1	0,10 M	52, 43 mho/cm
12.	X_2	0,15 M	34,25 mho/cm

13.	X ₃	0,20 M	14,64 mho/cm
14.	X ₄	0,25 M	4,24 mho/cm
15.	X ₅	0.30 M	0,16 mho/cm

Jika diketahui massa jenis vanadium pentaoksida=3,36 g/cm³, massa jenis air= 5 x 10⁻⁸ mho/cm dengan suhu 25°C. Luas permukaan airnya 25 cm². Tentukanlah konduktivitas dari ion V₂O₅

Jawaban:

$$R = \rho \times \frac{l}{A}$$

$$R = \frac{3,36 \text{ g}}{\text{cm}^3} \times \frac{5 \times 10^{-8} \text{ mho/cm}}{25 \text{ cm}^2}$$

$$R = 0,672 \times 10^{-8} \text{ mho g cm}^{-2}$$

$$k = \frac{1}{RA}$$

$$k = \frac{1}{0,672 \times 10^{-8} \text{ mho g cm}^2 \cdot 25 \text{ cm}^2}$$

$$k = 0,059 \times 10^8 \text{ mho/cm}$$

Jika diketahui massa jenis (173-175) vanadium pentaoksida=3,36 g/cm³, massa jenis air= 5 x 10⁻⁸ mho/cm dengan suhu 25°C. Luas permukaan airnya 25 cm². Tentukanlah konduktivitas dari ion V₂O₅

Jawaban:

$$R = \rho \times \frac{l}{A}$$

$$R = \frac{3,36 \text{ g}}{\text{cm}^3} \times \frac{5 \times 10^{-8} \text{ mho/cm}}{25 \text{ cm}^2}$$

$$R = 0,672 \times 10^{-8} \text{ mho g cm}^{-2}$$

$$k = \frac{1}{RA}$$

$$k = \frac{1}{0,672 \times 10^{-8} \text{ mho g cm}^2 \cdot 25 \text{ cm}^2}$$

$$k = 0,059 \times 10^8 \text{ mho/cm}$$

11. Besaran $KF3$

Menggunakan rumus-rumus yang dapat menghitung besaran dari senyawa vanadium entaoksida.

Berdasarkan Teori Termodinamika

- a. Gaya termodinamika gradien konsentrasi

Dalam larutan(176) dengan aktivasi partikel α , maka potensial kimianya :

$$\mu = \mu^\theta + RT \ln \alpha \quad (1)$$

Jika larutan tidak seragam, aktivitas itu bergantung pada posisinya dan kita dapat menuliskan :

$$T_e = -RT \left(\frac{\delta \ln \alpha}{\delta x} \right)_{p,T} \quad (2)$$

Jika larutan itu ideal, α dapat digantikan dengan konsentrasi c , sehingga :

$$T_e = \frac{-RT}{c} \left(\frac{\delta c}{\delta x} \right)_{p,T} \quad (3)$$

Karena $(d/dx) \ln c = 1/c \, dc/dx$

- b. Hukum pertama Fick tentang difusi

Andaikan fluks partikel yang berdifusi(177-180), merupakan gerakan sebagai reaksi terhadap gaya termodinamika yang timbul dari gradient konsentrasi(181-183). Partikel akan mencapai kecepatan hanyut tetap s jika gaya termodinamika(184-187) f sama dengan tahanan kental.kecepatan hanyut ini sebanding dengan gaya termodinamika (188), dan kita tuliskan $s \propto f$. Akan tetapi, fluks(131; 189; 190) partikel J sebanding dengan kecepatan hanyut, dan gaya termodinamika sebanding dengan gradient konsentrasi(191-194) dc/dx . Rantai kesebandingan itu ($J \propto s$, $s \propto f$, dan $f \propto dc/dx$) menunjukkan bahwa:

$$J \propto \frac{dc}{dx} \quad (4)$$

Yang merupakan kandungan hukum Fick

- c. Hubungan Einstein

Hukum Fick untuk fluks partikel dalam mol molekul per satuan luas per satuan waktu adalah:

$$J = -D \frac{dc}{dx} \quad (5)$$

Dengan D merupakan koefisien difusi(195-197) dan dc/dx merupakan kemiringan dari konsentrasi molar(198-200). Fluks partikel berhubungan dengan kecepatan hanyut, dengan:

$$J = sc \quad (6)$$

12. Energy Stability

Optimasi(201) dengan menggunakan MM2 ada Chemdraw 3d.

Pada Dynamic

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

Note: 1,3 van der Waals interactions are used to compute the energy of angles around atoms with more than 4 coordinate bonds.

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

Iteration Time Total Energy Potential Energy Temperature

1	0.002	81.110 ± 0.000	81.110 ± 0.000	0.00 ± 0.00
2	0.004	82.300 ± 0.000	81.783 ± 0.000	6.94 ± 0.00
3	0.006	83.607 ± 0.000	82.866 ± 0.000	9.95 ± 0.00
4	0.008	83.591 ± 0.000	82.223 ± 0.000	18.35 ± 0.00
5	0.010	83.454 ± 0.000	82.257 ± 0.000	16.05 ± 0.00
6	0.012	84.778 ± 0.000	83.311 ± 0.000	19.69 ± 0.00
7	0.014	85.667 ± 0.000	83.788 ± 0.000	25.22 ± 0.00
8	0.016	85.810 ± 0.000	83.892 ± 0.000	25.74 ± 0.00
9	0.018	85.531 ± 0.000	83.123 ± 0.000	32.31 ± 0.00
10	0.020	86.386 ± 0.000	83.850 ± 0.000	34.03 ± 0.00
11	0.022	87.914 ± 0.000	85.605 ± 0.000	30.98 ± 0.00
12	0.024	88.010 ± 0.000	84.946 ± 0.000	41.12 ± 0.00
13	0.026	87.501 ± 0.000	84.399 ± 0.000	41.64 ± 0.00
14	0.028	87.557 ± 0.000	84.830 ± 0.000	36.59 ± 0.00
15	0.030	88.674 ± 0.000	85.316 ± 0.000	45.07 ± 0.00
16	0.032	90.036 ± 0.000	86.891 ± 0.000	42.20 ± 0.00
17	0.034	90.188 ± 0.000	86.729 ± 0.000	46.42 ± 0.00
18	0.036	90.582 ± 0.000	85.991 ± 0.000	61.60 ± 0.00
19	0.038	90.880 ± 0.000	86.465 ± 0.000	59.24 ± 0.00
20	0.040	91.382 ± 0.000	86.668 ± 0.000	63.26 ± 0.00
21	0.042	93.149 ± 0.000	88.448 ± 0.000	63.09 ± 0.00
22	0.044	92.182 ± 0.000	86.917 ± 0.000	70.65 ± 0.00
23	0.046	91.243 ± 0.000	84.924 ± 0.000	84.79 ± 0.00
24	0.048	93.513 ± 0.000	87.917 ± 0.000	75.09 ± 0.00
25	0.050	95.500 ± 0.000	89.309 ± 0.000	83.08 ± 0.00
26	0.052	95.437 ± 0.000	87.448 ± 0.000	107.20 ± 0.00
27	0.054	92.953 ± 0.000	85.024 ± 0.000	106.41 ± 0.00
28	0.056	93.645 ± 0.000	86.987 ± 0.000	89.34 ± 0.00
29	0.058	98.756 ± 0.000	92.032 ± 0.000	90.24 ± 0.00
30	0.060	97.586 ± 0.000	89.269 ± 0.000	111.61 ± 0.00
31	0.062	95.124 ± 0.000	87.407 ± 0.000	103.56 ± 0.00
32	0.064	97.066 ± 0.000	90.516 ± 0.000	87.90 ± 0.00
33	0.066	98.447 ± 0.000	91.732 ± 0.000	90.11 ± 0.00
34	0.068	99.992 ± 0.000	91.524 ± 0.000	113.65 ± 0.00
35	0.070	96.856 ± 0.000	88.039 ± 0.000	118.32 ± 0.00
36	0.072	96.733 ± 0.000	89.970 ± 0.000	90.75 ± 0.00
37	0.074	101.849 ± 0.000	93.697 ± 0.000	109.40 ± 0.00
38	0.076	99.739 ± 0.000	89.510 ± 0.000	137.27 ± 0.00
39	0.078	98.482 ± 0.000	89.599 ± 0.000	119.20 ± 0.00
40	0.080	99.841 ± 0.000	91.375 ± 0.000	113.61 ± 0.00
41	0.082	99.801 ± 0.000	91.136 ± 0.000	116.28 ± 0.00
42	0.084	102.531 ± 0.000	93.460 ± 0.000	121.73 ± 0.00
43	0.086	99.918 ± 0.000	89.247 ± 0.000	143.20 ± 0.00
44	0.088	98.683 ± 0.000	89.301 ± 0.000	125.90 ± 0.00
45	0.090	102.550 ± 0.000	93.027 ± 0.000	127.80 ± 0.00

46	0.092	102.453 ± 0.000	91.678 ± 0.000	144.59 ± 0.00
47	0.094	103.326 ± 0.000	93.074 ± 0.000	137.58 ± 0.00
48	0.096	101.766 ± 0.000	90.474 ± 0.000	151.54 ± 0.00
49	0.098	102.595 ± 0.000	91.648 ± 0.000	146.89 ± 0.00
50	0.100	110.005 ± 0.000	99.335 ± 0.000	143.18 ± 0.00
51	0.102	104.348 ± 0.000	90.229 ± 0.000	189.47 ± 0.00
52	0.104	100.539 ± 0.000	88.121 ± 0.000	166.63 ± 0.00
53	0.106	107.755 ± 0.000	95.899 ± 0.000	159.10 ± 0.00
54	0.108	106.443 ± 0.000	92.764 ± 0.000	183.56 ± 0.00
55	0.110	102.348 ± 0.000	90.064 ± 0.000	164.83 ± 0.00
56	0.112	101.088 ± 0.000	89.836 ± 0.000	150.99 ± 0.00
57	0.114	104.798 ± 0.000	93.760 ± 0.000	148.12 ± 0.00
58	0.116	112.430 ± 0.000	99.517 ± 0.000	173.28 ± 0.00
59	0.118	106.221 ± 0.000	91.375 ± 0.000	199.23 ± 0.00
60	0.120	103.742 ± 0.000	91.572 ± 0.000	163.32 ± 0.00
61	0.122	114.198 ± 0.000	102.978 ± 0.000	150.57 ± 0.00
62	0.124	110.206 ± 0.000	94.836 ± 0.000	206.25 ± 0.00
63	0.126	105.492 ± 0.000	91.494 ± 0.000	187.85 ± 0.00
64	0.128	108.210 ± 0.000	95.901 ± 0.000	165.18 ± 0.00
65	0.130	108.452 ± 0.000	95.722 ± 0.000	170.83 ± 0.00
66	0.132	110.743 ± 0.000	96.799 ± 0.000	187.12 ± 0.00
67	0.134	108.986 ± 0.000	93.140 ± 0.000	212.64 ± 0.00
68	0.136	107.598 ± 0.000	91.864 ± 0.000	211.15 ± 0.00
69	0.138	111.475 ± 0.000	96.846 ± 0.000	196.31 ± 0.00
70	0.140	110.458 ± 0.000	96.239 ± 0.000	190.82 ± 0.00
71	0.142	111.584 ± 0.000	96.608 ± 0.000	200.97 ± 0.00
72	0.144	112.875 ± 0.000	96.992 ± 0.000	213.14 ± 0.00
73	0.146	111.351 ± 0.000	95.716 ± 0.000	209.81 ± 0.00
74	0.148	118.083 ± 0.000	101.577 ± 0.000	221.50 ± 0.00
75	0.150	116.409 ± 0.000	95.810 ± 0.000	276.43 ± 0.00
76	0.152	118.295 ± 0.000	100.251 ± 0.000	242.15 ± 0.00
77	0.154	144.357 ± 0.000	120.537 ± 0.000	319.65 ± 0.00
78	0.156	132.581 ± 0.000	97.483 ± 0.000	471.00 ± 0.00
79	0.158	236.778 ± 0.000	189.022 ± 0.000	640.86 ± 0.00

Dynamics terminated because the molecular model is too far from equilibrium

Pada Properties

MM2 Calculation completed successfully

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

Note: 1,3 van der Waals interactions are used to compute the energy of angles around atoms with more than 4 coordinate bonds.

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

Stretch:	2656.4850
Bend:	52.7655
Stretch-Bend:	0.5057
Torsion:	0.0000
Non-1,4 VDW:	-1.1252
1,4 VDW:	9.7376
Dipole/Dipole:	13.2043
Total Energy:	2731.5730 kcal/mol

The total energy for this frame: 2731.573 kcal/mol
Calculation ended

13. Discussion

Materi didapatkan berdasarkan pada diskusi dan beberapa referensi.

Kegunaan

Vanadium pentaoksida dapat digunakan sebagai katalis dalam pembuatan asam(202) sulfat (203-209) dan anhidrat maleat serta dalam pembuatan keramik. Pada pembuatan keramik, V_2O_5 digunakan sebagai pemberi warna coklat hingga hijau pada larutan.

Bahaya

Asap Vanadium Pentaoksida dapat menyebabkan iritasi (210-215) parah pada mata, kulit, saluran pernapasan, radang trakea dan bronkus, edema paru-paru serta keracunan sistemik(85; 216; 217).

14. Kesimpulan

Vanadium Pentaoksida mengandung ikatan ionic di dalam larutan walapun ikatannya lemah atau disebut juga elektrolit(150) lemah. Transfer ionic(218) di dalam larutan membentuk anion dan kation, dimana anion berupa oksigen dan kationnya berupa vanadium. Konduktifitas pada vanadium pentaoksida dapat menghantarkan arus listrik dengan memiliki titik leburnya yang rendah dimana didapatkan $0,059 \times 10^8 \text{ mho/cm}$. Vanadium pentaoksida dilihat interaksi molekular(101) dengan menentukan konduktifitas, daya hanyut, viskositas dan transfer ionic pada larutannya. Sifat termodinamikanya yaitu $\Delta S^\circ = 131 \text{ J/mol K}$, $\Delta_f^\circ H = -1550,6 \text{ KJ/mol}$, $\Delta_f^\circ G = -1419,5 \text{ KJ/mol}$, $C_p = 127,7 \text{ J/mol K}$.

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