THE DIELECTRIC CONSTANT OF LIQUID HFC 32

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INTRODUCTION

The study of the properties of the new alternative refrigerants is important in order to accelerate the process of substitution of the old fully halogenated refrigerants. Some parameters such as ODP, GWP and TEWI contribute to the choice of the new compounds. The hydrocarbon, difluoromethane (HFC 32, $CH_2 F_2$) is expected to be a promising component of the binary and/or ternary refrigerant mixtures (blends with HFC 134a and/or HFC 125) to replace chlorodifluoromethane (HCFC 22, $CHClF_2$) because of its zero ozone-depleting potential. HCFC 32 is a widely used refrigerant in domestic and industrial applications. Difluoromethane is an especially interesting fluid because of its large dipole moment (1.98 D). However some precautions must be taken because of its flammability.

The dielectric constant provides information about the behavior of the molecules under an electrical field and it is related to the state of the molecules such as the chemical structure and molecular interactions between them.

The data have been obtained as a function of temperature and pressure and each isotherm was correlated in terms of pressure and density.

EXPERIMENTAL

The experimental setup is based on a three terminal arrangement and the dielectric constant ε was obtained from the ratio between the ratio of the capacitances of the cell with the sample and under vacuum. The instrument has been thoroughly documented in earlier publications /1,2/ and is only briefly described here.

The capacitance of the cell was measured in an absolute mode using an Impedance Analyzer (Schlumberger, type SI 1260) with a precision of $\pm 5 \times 10^{-4}$ pF. The capacitance of the cell under vacuum was approximately 5.7 pF. The temperature was measured with a calibrated platinum resistance thermometer with an accuracy of 5 mK. The pressure vessel was immersed in a circulating flow thermostated bath with a stability of 10 mK during 1 hour. An industrial cryostat provided the circulating liquid. The pressure was measured with a pressure transducer calibrated with an accuracy of 0.01 MPa.

The sample was provided by Solvay und Derivatives and was used without further purification. The estimated purity is 99.8 %. Molecular sieves have been used to extract the water before filling the cell.

RESULTS

Table 1 shows the data obtained at the several isotherms between 208 and 304 K as a function of pressure. The value of the accuracy of the dielectric constant measurements is estimated to be 0.1 % (Ref. /3/). The density values were derived using the BWR equation of state with the parameters provided by McLinden et al. /4/. The estimated uncertainty of these values as reported is 0.14%.

P **/ MPa**	*r* **/ kg.m^{-3}**	*e*	***P*** **/ MPa**	*r* **/ kg.m^{-3}**	*e*
T **= 303.784 K**			***T*** **= 243.602 K**		
14.74	1005.66	14.051053	16.09	1182.37	23.173805
14.08	1002.95	13.997716	15.00	1180.36	23.121315
13.01	998.43	13.920785	14.00	1178.49	23.074254
12.01	994.04	13.838972	13.00	1176.60	23.021764
10.99	989.40	13.754177	12.03	1174.73	22.974704
10.02	984.82	13.670285	11.01	1172.75	22.922214
9.01	979.84	13.581149	10.00	1170.75	22.876964
8.01	974.70	13.486048	9.02	1168.78	22.822663
7.02	969.36	13.389499	8.01	1166.73	22.770173
6.00	963.59	13.290872	7.05	1164.75	22.714063
5.01	957.64	13.180854	6.00	1162.54	22.659763
4.00	951.27	13.066407	5.00	1160.40	22.607273
3.01	944.59	12.945993	4.00	1158.25	22.558402
2.01	937.36	12.815634	3.06	1156.18	22.500482
			2.00	1153.81	22.446182
T **=293.932 K**			***T*** **= 234.465 K**		
15.11	1038.32	15.349471	16.05	1205.81	24.929018
14.00	1034.41	15.263032	15.05	1204.14	24.884846
13.00	1030.78	15.186178	14.02	1202.40	24.837778
12.00	1027.04	15.109323	13.02	1200.69	24.788900
11.00	1023.19	15.039521	12.03	1198.98	24.741832
10.03	1019.34	14.965560	11.01	1197.19	24.694764
9.01	1015.15	14.891237	10.00	1195.39	24.644075
8.00	1010.85	14.806787	9.09	1193.75	24.602438
7.01	1006.45	14.721433	8.02	1191.81	24.549939
6.00	1001.84	14.642047	7.00	1189.92	24.501061
5.01	997.10	14.549460	6.02	1188.09	24.452182
4.01	992.08	14.456692	5.00	1186.15	24.399683
3.00	986.82	14.362116	4.11	1184.43	24.352615
2.00	981.31	14.266273	3.01	1182.29	24.296496
			2.03	1180.35	24.245807
T **= 284.128 K**			***T*** **= 223.252 K**		
12.78	1060.76	16.604394	17.41	1236.05	27.336241
12.00	1058.24	16.549592	16.01	1234.00	27.274678
11.00	1054.93	16.484082	15.00	1232.50	27.227600
10.00	1051.53	16.411988	14.00	1231.00	27.184144
9.01	1048.05	16.344670	13.02	1229.52	27.138877
8.03	1044.55	16.274855	12.00	1227.95	27.091800
7.00	1040.74	16.201423	11.01	1226.42	27.046533
6.01	1036.95	16.126002	10.01	1224.85	27.001266
5.00	1032.97	16.055645	9.01	1223.27	26.954188
4.00	1028.88	15.972265	8.00	1221.65	26.907110
3.00	1024.65	15.888343	7.02	1220.06	26.867275
2.01	1020.30	15.808038	6.01	1218.40	26.820198
			5.04	1216.79	26.778552
			4.03	1215.10	26.729664
			3.01	1213.36	26.664479
			2.00	1211.63	26.613780

T = 274.356 K			*T* = 215.229 K		
16.10	1099.13	18.191348	16.12	1254.01	29.031724
15.01	1096.24	18.131651	14.99	1252.47	28.982828
14.02	1093.57	18.071050	14.00	1251.10	28.937555
13.01	1090.79	18.009002	13.01	1249.72	28.885037
12.01	1087.96	17.950571	12.05	1248.37	28.845197
11.01	1085.10	17.886352	11.00	1246.88	28.792679
9.99	1082.10	17.824304	10.01	1245.45	28.743784
9.02	1079.18	17.764064	9.005	1244.00	28.700321
8.03	1076.13	17.701112	8.00	1242.52	28.655048
6.99	1072.84	17.635626	7.00	1241.04	28.606152
5.97	1069.53	17.567246	6.00	1239.54	28.559068
4.00	1062.88	17.432476	4.98	1238.00	28.508361
3.00	1059.36	17.359574	4.01	1236.52	28.455844
2.00	1055.73	17.285586	2.97	1234.91	28.406948
			2.03	1233.44	28.359864
T = 264.612 K			*T* =208.421 K		
16.01	1126.09	19.602273	17.00	1271.76	30.678113
15.00	1123.72	19.549803	16.02	1270.52	30.643701
14.00	1121.33	19.497333	15.02	1269.25	30.603856
13.02	1118.94	19.443053	14.00	1267.93	30.560388
12.00	1116.42	19.386964	13.05	1266.70	30.515108
11.00	1113.89	19.330876	12.00	1265.32	30.455340
10.03	1111.40	19.273882	11.01	1264.01	30.445378
9.01	1108.72	19.216889	10.00	1262.66	30.384704
8.00	1106.01	19.157182	9.01	1261.33	30.319502
7.01	1103.30	19.097474	8.00	1259.95	30.286901
6.00	1100.49	19.035958	7.02	1258.60	30.247056
5.00	1097.64	18.976250	6.03	1257.23	30.203588
4.01	1094.75	18.912924	5.09	1255.91	30.161931
3.00	1091.72	18.849598	4.05	1254.44	30.107596
2.01	1088.69	18.782654	3.05	1253.01	30.058694
			2.05	1251.56	29.997114
T = 253.047 K					
16.02	1157.39	21.477693			
15.00	1155.30	21.425212			
14.00	1153.22	21.378160			
12.99	1151.08	21.322059			
12.02	1149.00	21.271388			
11.01	1146.80	21.218907			
10.01	1144.58	21.166426			
9.00	1142.30	21.108515			
8.00	1140.01	21.056034			
7.01	1137.70	20.999934			
5.99	1135.28	20.940214			
5.04	1132.99	20.885923			
4.05	1130.55	20.833442			
2.99	1127.89	20.770102			
2.05	1125.49	20.719431			

Table 1: Experimental data for the dielectric constant of HFC 32.

Figure 1 shows the dependence of the dielectric constant of HFC 32 on temperature and pressure and figure 2 its dependence on density and temperature.

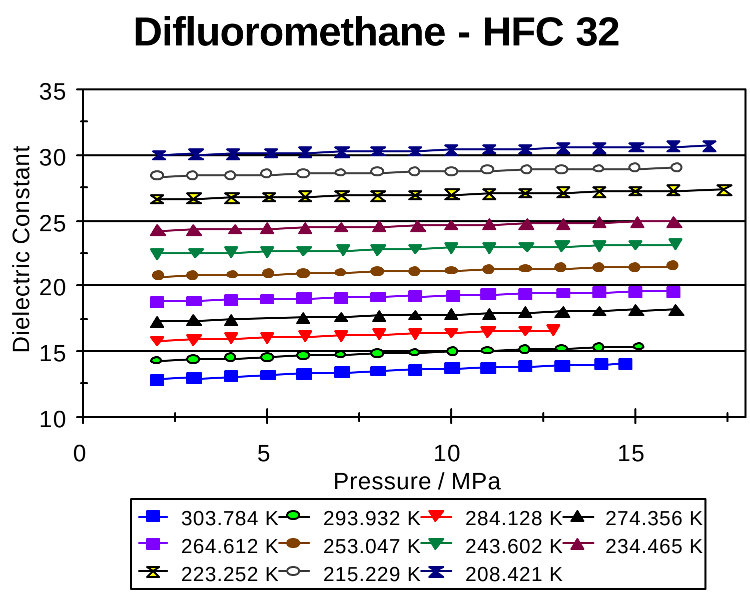

Figure 1. The dielectric constant of HFC 32 as a function of pressure for different isotherms.

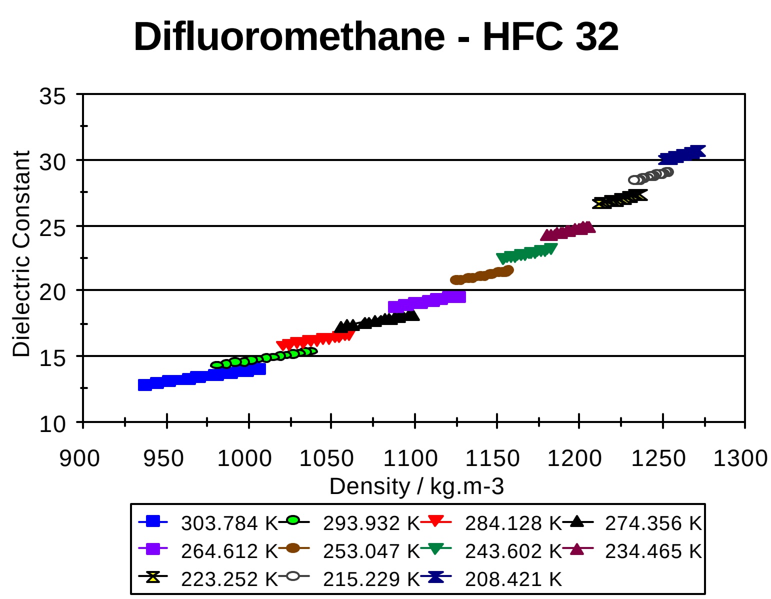

Figure 2. The dielectric constant of HFC 32 as a function of density for different isotherms.

For practical purpose a correlation of the data obtained has been performed as a function of pressure:

$$e = \sum_{i=0}^{2} a_i \cdot P^i \qquad (1)$$

where P / MPa.

The values of the coefficients a_i are presented on Table 2. The deviations from the fit do not exceed 0.05 %.

T/K	a_o	± *s* ´ 10^3	a_1	± *s* ´ 10^3	a_2 ´ 10^3	± *s* ´ 10^5
303.78	12.5669	5.17	.13246	1.70	-2.19	9.8
293.93	14.0753	5.53	.09943	1.76	-1.04	10.1
284.13	15.6406	3.03	.08590	1.30	-0.84	8.6
274.36	17.1438	2.47	.07366	0.70	-0.54	3.8
264.61	18.6518	1.00	.06670	0.29	-0.47	1.6
253.05	20.5957	1.96	.05960	0.57	-0.28	3.1
243.60	22.3321	2.69	.05665	0.77	-0.27	4.2
234.46	24.1393	1.26	.05317	0.36	-0.25	2.0
223.25	26.5219	5.15	.05015	1.29	-0.20	6.5
215.23	28.2592	2.72	.05035	0.78	-0.15	4.2
208.42	29.9024	9.36	0.0511	2.43	-0.31	12.5

Table 2: Coefficients of fitting of dielectric constant data as a function of pressure for the several isotherms.

CONCLUSION

The present paper reports values of dielectric constant of HFC 32 as a function of pressure at several isotherms between 208 and 304 K and pressures up to 18 MPa, with an accuracy of 0.1 %. For industrial applications a correlation of the data obtained is presented as a function of pressure. No other results were found in the literature for the dielectric constant of this halocarbon.

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SYMBOLS

a_i - coefficients of Eq. (1). n=0,1,2.
P - pressure, in MPa
T - temperature, in K
e - dielectric constant
s - mean square deviation of the coefficients of Eq. (1)
r - density, in kg.m^3

SUMMARY

Dielectric constant measurements have been performed in the liquid phase for HFC 32 (difluoromethane) in the temperature range between 208 K and 304 K and pressures from the saturation up to 18 MPa.

The measurements were carried out with a direct method using an Impedance Analyzer. The estimated uncertainty for the data obtained is 0.01% and the accuracy is 0.1%. The data were correlated as a function of pressure.