Asian Journal of Chemistry; Vol. 26, No. 18 (2014), 6212-6214

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2014.17182

Study on $KMnO_4$ and CH_3COOK Properties in Microwave Chemical Reactors

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Received: 8 February 2014; *Accepted*: 10 April 2014; *Published online*: 1 September 2014; AJC-15884

In this paper, the changes of complex dielectric property of the potassium permanganate ($KMnO_4$) and potassium acetate (CH_3COOK) with different power are calculated and measured. The dielectric property of electrolyte solution with sylvine is studied. It is shown that the changes of real part of the complex permittivity are all small and the changes of the imaginary part of the complex permittivity of electrolyte solution are obvious. By analyzing the systems and variation error with different power, a conclusion is drawn that the measured results are credible and it is found that the imaginary part of K^+ electrolyte solution permittivity is directly relative to power. What's more, this method makes it possible to analyze the nonlinear time-dependent changing of reflection and absorption of microwave by the reactants and it is helpful for the design of microwave chemical reactors.

Keywords: Potassium permanganate, Potassium acetate, Temperature-dependent, Numerical calculation.

INTRODUCTION

The conventional methods are not adequate, remote sensing can play an important role in solving these problems. The electromagnetic spectrum with different wavelength bands has applications in diverse areas. With increase in demand for natural resources, non-availability causes scarcity and one has to identify the factors behind these. According to operating wavelength band, ultraviolet remote sensing, visual spectrum remote sensing, infrared remote sensing, microwave remote sensing and multispectral remote sensing are included in remote sensing system. In this paper, the dielectric measurement of chemical solution is under the microwave sensing frequency range.

These properties are drastically affected by the presence of a dopant in the polymer[1-5]. Dielectric measurements such as dielectric constant, dielectric loss and relaxation time reveal significant information about the chemical and physical characteristics of solution. The study of dielectric relaxation provides valuable information about intermolecular interaction and hence miscibility.

The effective permittivity extraction of the composite materials becomes more and more important for material design. In microwave remote sensing of soil moisture, it is important to determine the permittivity of soil as a function of soil moisture and soil types[6]. Sea ice is a mixture of ice and saline water and the effective permittivity determination is a critical issue[7]. The permittivities of dry and wet snow continue to draw interest[8]. In geophysical exploration, the permittivity of fluid filled porous rocks has to be studied[9].

In this paper, potassium permanganate and potassium acetate are on behalf of inorganic compounds and organic compounds respectively are chosen. Due to the sylvine is one of main pollutant in ground water, it is significant to study the characteristics of electrolyte solution with sylvine.

It is helpful to study non-thermal effect. In this paper, an effective measurement method and is proposed, Wien effect is studied by measuring solution permittivity changes, especially the imaginary part in relevant to conductivity changes with measurement power.

EXPERIMENTAL

Dielectric permittivity (ε) is a frequency-dependent parameter that describes the ability of the medium to polarize in response to an external electrical field.In dielectric permittivity, ε'_r is the real part, describing the ability of a material to store energy from an applied electrical field, ε''_r is the imaginary part, representing dielectric losses due to dissipation of energy by the material.

For the case that the ions all have the same size or that an effective ionic diameter is used[10,11]. On the basis of recent Fawcett's studies[12], the dependence of the effective permittivity of the solvent on electrolyte concentration (c_i) can be given by the expression:

$$e_{eff} = e_r - d_i c_i + b_i c_i^{3/2} \quad (1)$$

The shielding parameter is given by reference of Turq *et al.*[12]. Γ is the scaling parameter of the MSA (mean spherical approximation) theory, playing the role of the Debye inverse length K in the DH (Debye-Huckel) theory.

Where ε_r is the relative permittivity of pure solvent (78.45 for pure water), δ_I is the dielectric decrement for the electrolyte and b_i a parameter describing the curvature of the dependence. The effects of ion-ion interaction on the estimation of electrostatic contributions are greater than estimated on the basis of a constant ε_{ff} as a result of the increase of parameter Γ and decrease of ε_{ff} as concentration increases[12].

The experimental system is showed in Fig. 1. The reflection coefficients are obtained from a specially designed coaxial line probe with an Agilent E8362B microwave vector network analyzer. Meanwhile, KXS and a trough are employed to control the temperature of the solution in the beaker and the UMI-8 optical fiber thermometer is measured the temperature of the electrolyte solution.

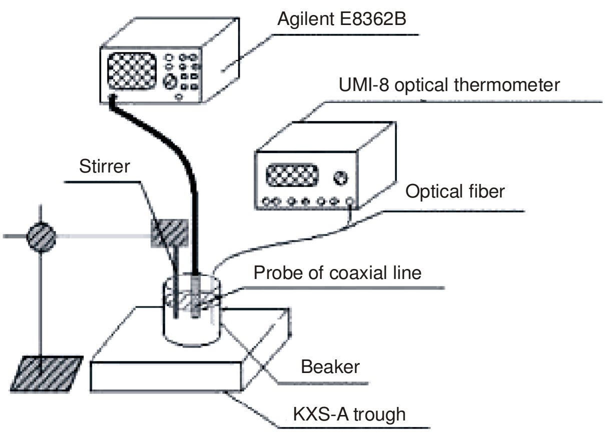

Fig. 1. Experimental system

RESULTS AND DISCUSSION

Table-1 shows the calculation complex permittivity values of K^+ electrolyte solution with potassium permanganate and potassium acetate, respectively change with incident power under 34 °C and 2.45 GHz. Figs. 2 and 3 show the measurement value and calculation value of the real part and imaginary part of potassium permanganate permittivity. Figs. 4 and 5 show the measurement value and calculation value of the real part and imaginary part of potassium acetate permittivity.

TABLE-1
EXPERIMENTAL COMPLEX PERMITTIVITY VALUES OF K^+ ELECTROLYTE SOLUTION (34°C, 2.45 GHZ)

Power (W)	Potassium permanganate		Potassium acetate	
	ε'_{eff}	ε''_{eff}	ε'_{eff}	ε''_{eff}
0.98	75.28093	52.47839	66.74933	22.69683
1.66	75.23708	52.04382	66.84948	21.80846
2.53	75.18178	51.67133	66.99016	20.48414
3.51	75.09852	51.28058	66.87094	18.86369
4.68	75.03432	50.36397	66.96874	18.93772
5.79	74.99237	49.40353	67.13323	19.76851
7.30	74.92945	48.57456	67.26254	20.92832
9.07	74.86716	47.98661	67.01162	20.95335
10.86	74.85381	48.78271	67.05455	22.10458
12.52	74.84809	49.63366	67.05455	23.19036
14.76	74.80424	49.84906	67.22623	23.23149
16.84	74.77945	49.89288	67.35499	24.46533
19.29	74.75339	49.72124	67.38361	25.46886
21.91	74.68665	49.50213	67.44562	26.20917
24.49	74.63517	49.52404	67.39076	28.22444

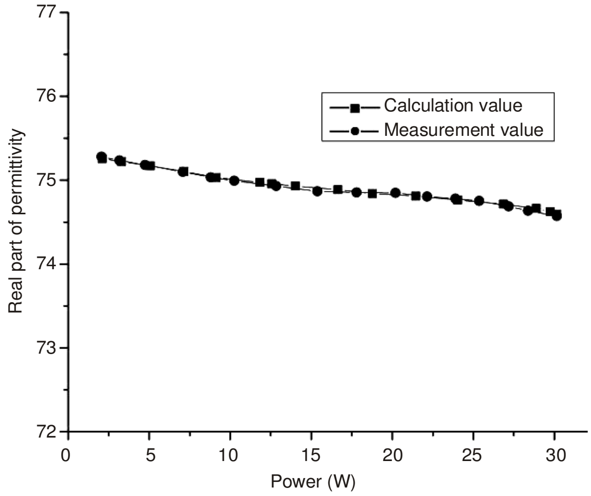

Fig. 2. Real part of potassium permanganate permittivity

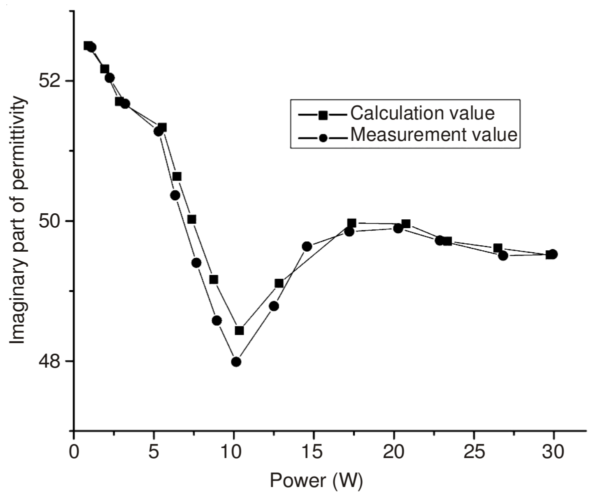

Fig. 3. Imaginary part of permanganate potassium permittivity

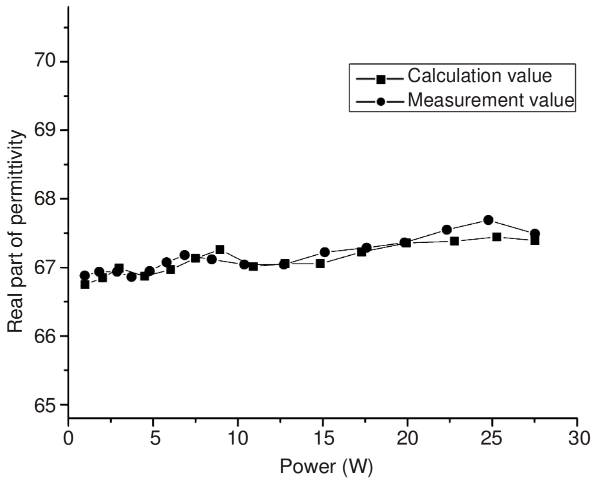

Fig. 4. Real part of potassium acetate permittivity

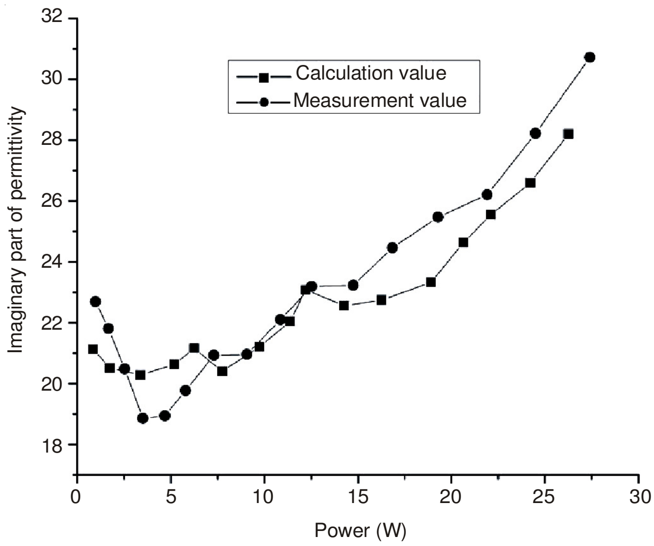

Fig. 5. Imaginary part of potassium acetate permittivity

From Table-1 and Figs. 2 to 5, the variations of real part and imaginary part of complex permittivity values of K^+ electrolyte solution changes with incident power are analyzed.

In Figs. 2 and 4, the real part of potassium permanganate and potassium acetate permittivity are reduced by a little with the incident power. The maximum relative variations are only 0.94 and 1.03 %. But from Figs. 3 and 5 it is observed that the changes of imaginary part are very obvious. The maximum relative variations are set at 8.56 and 12 %, respectively. From Figs. 2 to 5 it is observed that the measured permittivity reasonably agrees with the calculated results.

There is a inflection point in the course of the imaginary part variation when the incident power is changed, whether the potassium permanganate or potassium acetate electrolyte solution. It is related to the molecular structure of electrolyte solution.

Conclusion

Under the band of microwave remote sensing, it is quite obvious that the imaginary part of complex permittivity of K^+ electrolyte solution changes with the increase of microwave power. From non-thermal problem affected by microwave, it is found that the imaginary part of K^+ electrolyte solution permittivity is directly relative to power. In addition, this method makes it possible to analyze the nonlinear time-dependent changing of reflection and absorption of microwaves by the reactants and it is helpful for the design of microwave chemical reactors.

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