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Note

Weak transverse magnetic field effect on the viscosity of KCl-H_2O solution

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This work describes the applied traverse magnetic field effect on the viscosity of the diamagnetic KCl–H_2O solution at 25°C temperature (Table 1, Fig. 1). It was found that the applied transverse magnetic field increases the viscosity of this solution in such a way that in the limit of infinite dilution the viscosity increase approaches the already observed magnetic field effect on the viscosity of the pure water[1,2]. This,

TABLE 1

SUMMARY OF RESULTS

Conc. (mol l^{-1})	*Arithmetic mean fractional viscosity* $v^* = [(v^H - v^\circ)/v^\circ] \times 10^2$	*Statistical analysis*[a]	
		Standard deviation[b], σ_H	*Null hypothesis with* $\mu_H = \mu_o$; $\sigma_h \neq \sigma_o$
0.010	0.2419	5.8201×10^{-4}	Rejected at 99% confidence level
0.100	0.2241	2.8869×10^{-4}	Rejected at 99% confidence level
0.500	0.2117	4.7321×10^{-4}	Rejected at 99% confidence level
1.000	0.1978	2.4682×10^{-4}	Rejected at 99% confidence level
1.500	0.0884	1.5931×10^{-4}	Rejected at 95% confidence level
3.000	0.0717	6.4631×10^{-4}	Rejected at 90% confidence level

[a] For detailed discussion regarding the use of statistical analysis methods please refer to any standard textbook.

[b] Standard deviation, σ_x is defined as:

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$$

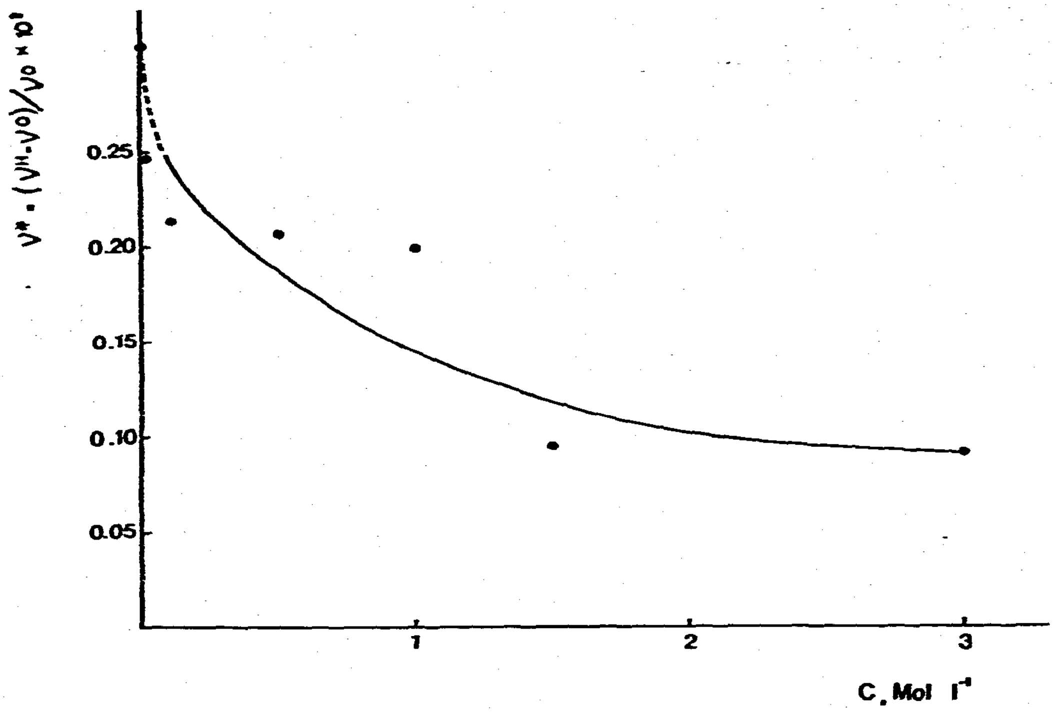

Fig. 1. Relation between the fractional mean average viscosity $\nu^* = [(\nu^H - \nu^0)/\nu^0] \times 10^2$ and the concentration of KCl–H_2O solution. Dashed line (— — —) indicates the extrapolation to the experimentally observed ν^*-change of the pure water[1,2].

therefore, strongly supports the recent findings by Lielmezs et al.[1] and Lielmezs and Aleman[2] that an externally applied magnetic field weakly increases the viscosity of the pure distilled water.

EXPERIMENTAL

The recent papers by Lielmezs et al.[1] and Lielmezs and Aleman[2–4] describe in detail the apparatus and methods used for the measurement and evaluation of the transverse applied magnetic field effect of the viscosity of pure distilled water[1,2] and a series of paramagnetic nitrate–water solutions[3,4]. As previously described[1–4], the measuring apparatus consists of two parts: the electromagnet system and the viscometer–temperature bath assembly. The same Cannon–Fenske opaque (calibrated, reverse flow, No. 50, V-561) viscometer was retained for use in this work. The same viscometer cleaning and measurement procedures as well as calculation methods were used in this work. As a result of this, the overall accuracy of this work is expected to be at the same accuracy level as found and in detail discussed in our previous work[1–4].

RESULTS AND DISCUSSION

Following the calculation methods of our previous work[1-4], the viscosity of KCl–H_2O solution for both, the applied and the no applied (ambient earth magnetic field) magnetic field condition, was calculated from the simplified expression:

$$v = C \times t \tag{1}$$

where: v = viscosity in stokes; C = constant (determined by calibration); t = efflux time in seconds.

The results of this study are given in Table 1 and Fig. 1. Table 1 presents for all concentrations of KCl–H_2O solution, at 25°C temperature and the magnetic field strength $H = 12$ kG, the fractional viscosity coefficient, defined as $v^* = [(v^H - v^\circ)/v^\circ] \times 10^2$, where v^H is the arithmetic mean average viscosity at the 25°C temperature and the applied magnetic field strength $H = 12$ kG. The v°, however, is the arithmetic mean average viscosity at the ambient earth magnetic field (or no-field condition) while v^H then is the corresponding viscosity value at the given applied magnetic field strength H.

Table 1 also presents statistical analysis data, standard deviation, σ_H, calculated at the applied magnetic field strength $H = 12$ kG, and the t-distribution null-hypothesis results assuming that the means are equal ($\mu_H = \mu_0$) while the variances for the applied field and no-field conditions are not equal, that is, $\sigma_H \neq \sigma_0$.

The obtained results (Table 1, Fig. 1) show that within the bounds of our measurements, the present v^*–C plot (Fig. 1) is monotonically smooth curve, and at constant magnetic field strength H and temperature T; increasing in such a way as to at the infinite dilution finally to approach the already observed magnetic field effect on the viscosity of pure distilled water under the same magnetic field and temperature conditions[1,2]. This limiting behavior of the very dilute KCl–H_2O solution viscosity under the influence of an applied magnetic field strongly supports our previous findings that an applied external magnetic field increases the viscosity of the pure water[1,2]. Whether this finding indicates that diamagnetic liquid viscosity, in general, will increase under the influence of an applied magnetic field, is a question worthy of further study. However, this thought is greatly substantiated through our findings[3,4] that for the paramagnetic nitrate–water solutions, first, at high concentrations the viscosity decreases under the influence of an applied magnetic field; and then, at low concentrations, the applied magnetic field increases the viscosity of the paramagnetic nitrate–water solutions, again in such a way as the observed viscosity increase for the paramagnetic nitrate–water solutions in the limit approaches the already measured viscosity increase of the diamagnetic pure water[3,4].

The exact mechanism for the observed viscosity changes as caused by the applied magnetic field cannot be understood with certainty at the present. However, it might be of interest to study the reported magnetic field effect on the solution viscosity in terms of the various microstructural processes of the KCl–H_2O solution recalling that any changes observed in shear viscosity are determined by the rates of the involved molecular reorientational and translational motions[1-4]. These, as already stated by Lielmezs et al.[1] and Lielmezs and Aleman[2-4] are essentially two interaction mechanisms: the dipolar interaction chiefly associated with the proton longitudinal relaxation time determining the diamagnetic liquid (water) behavior; and the spin exchange mechanism associated with the proton transverse relaxation time and determining the paramagnetic nitrate–water solution behavior.

ACKNOWLEDGEMENT

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