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Viscosities (η) of Polyvinyl Pyrrolidone in its Aqueous Solutions at 292.9 K

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The increasing magnitude of relative viscosity (η_r), specific viscosity (η_{sp}) and reduced viscosity (η_{red}) values of aqueous polyvinyl pyrrolidone (PVP) solutions with its concentration was marked to be directly correlated with its structural interactions with water molecules and hydrogen bonded water structure seems to be enhanced in presence of PVP molecules. The concentration effect was studied and the observations were seen to enhance the structure making effect of PVP on water. The hydrophilic and hydrophobic interactions between PVP and water molecules were seen to be going on and the torsional forces of PVP molecules and hydrogen bonded PVP in aqueous solution were seen to absorb some of the heat content from the solution itself.

INTRODUCTION

The viscosity measurements of polyvinyl pyrrolidone (PVP) in its aqueous solution and the processing of the experimental data at different concentrations was seen to be a research work of current interest to the expertise in the field of polymer science and other allied disciplines such as ion exchange technology, anticoagulating techniques of blood and structural determination of bigger organic molecules of great interest. The weakly solubilizing nature of these (PVP) polymers in water was observed to be a barrier for its viscosity measurements in its aqueous solutions in its wide concentration range. Despite the solubility barrier the viscosity measurements of the solutions of polyvinylrrolidone in a lower concentration range were made.

EXPERIMENTAL

The used polyvinyl pyrrolidone was of high degree of purity and of BDH grade. Demineralised double distilled water was used for its solution preparation by weight and a fairly constant 292.9 K temperature was maintained throughout the measurements.

The viscometer was kept in a water bath of 20 litre capacity and the solution injection was made by a thin one foot long plastic needle fitted with a syringe of 5 mL capacity. The weighed solution was added into the viscometer reservoir.

The flow time was measured for every solution of different concentration and its respective solvent by a most accurate watch.

RESULTS AND DISCUSSION

The measurement of flow time of the aqueous solutions of PVP with its different concentrations at a constant temperature was used to calculate the relative viscosity (η_r) as in equation.

$$\eta/\eta_0 = t_1\rho_1/\rho_0 t_0 \qquad (1)$$

where η_0, η is viscosity, ρ_0, ρ_1 is density and t_0 , t_1 is flow time of solvent and solute respectively and specific viscosity (η_{SP}) was evaluated using eqn. (2).

$$\eta_{sp} = (\eta - \eta_0)/\eta_0 \qquad (2)$$

where η is viscosity of the solution. The reduced viscosity (η_{red}) and intrinsic viscosity (η_{int}) were determined by eqns. (3) and (4).

$$\eta_{red} = \eta_{sp/c} \qquad (3)$$

$$\eta_{int} = (\eta_{sp/c})_{c \longrightarrow 0} \qquad (4)$$

where c was the concentration of the solute and (η_{int}) was directly obtained from the graph in Fig. 1.

The measured viscosities 1–3 of aqueous polyvinyl pyrrolidone (PVP) solutions at 292.9 K were observed to be higher (Fig. 1) than that of water (1.005 cp), the viscosity. of PVP, 0.02 g/cc PVP aqueous solution, was found to be 1.515 cp. These higher η_r values of PVP in its aqueous solution were seen as an evidence in favour of its more structured[4, 5] water-PVP solutions. The hydrogen bonding between water and PVP molecules was visualized to be stronger in presence of PVP which may be attributed to the aggregation of PVP molecules in aqueous solutions.

With concentration of the PVP in aqueous solutions, it was observed to be a considerable increase in the η (Fig. 1) values of aqueous PVP solutions which was further observed to be initially structured and then quickly establishing the hydrogen bonding between water and PVP molecules in solution. The polyvinyl pyrrolidone was marked with its concentration to bring about a favourable orientation[6, 7] for the hydrogen bonding between H_2O and PVP molecules in aqueous solutions. The bigger[8, 9] sized PVP molecules in their flow were observed to bring about a heat absorption phenomenon in its aqueous solution and the free flow of H_2O-PVP hydrogen bonded network in the viscometer was recorded to raise the flow time considerably which was assigned to the lowering of the solution temperature. The flow time for the same volume (25 cc) of water as well as 0.02 g/cc aqueous PVP solution was seen to be 170 and 257 seconds which was seen to show a clear-cut degree of solution structuredness.[10] The structural interactions between water and PVP molecules were recorded to be stronger (Fig. 2) and the intermolecular hydrogen bonding in water was seen to be less (Fig. 2) than that of water-PVP molecules and the degree of hydrogen bonding (Fig. 2) in aqueous-PVP molecules in solution with its concentration was seen to increase

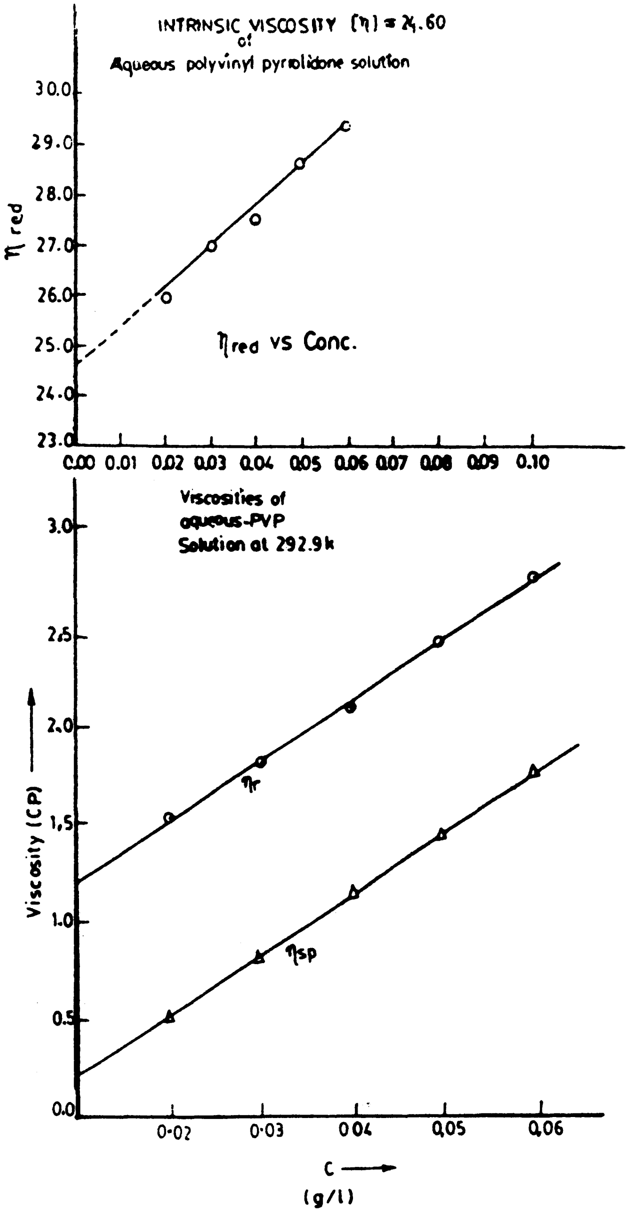

Fig. 1. Plot of viscosities of polyvinyl pyrrolidone in aqueous solution *vs.* its concentration.

in a higher proportion. The flow time for 0.06 g/cc aqueous PVP solution was observed to be 464 *i.e.*, almost two times that of 0.02 g/cc aqueous PVP solutions.

The stonger hydrogen bonding between water and PVP appeared to be torsional force resistant[11] during solution flow and the nature of polymer

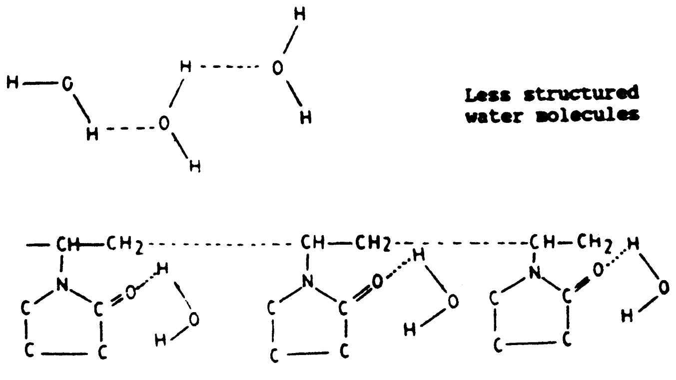

Fig. 2.

molecules appeared to form a coiled structure with respect to its ketonic functional group with water molecules in its aqueous solutions.

The increasing trend and tendency of relative viscosity (η_r) and specific viscosity (η_{sp}) (Fig. 1) of aqueous PVP solution with its concentration was found perhaps because of its available binding sites[12] ($>C^5{=}O$) with fresh PVP molecule addition in its aqueous solutions. The advanced understanding about the structural behaviour of PVP in its aqueous solutions was realised to be an asset to know about the anticoagulating[13] nature of blood plasma.

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