

Supporting documents

The viscosity method was successfully employed to determine influence of PVA on the Cr(III)-Sn(IV) doped indium nitrate in the precursor sol, since the viscosity experiments can only be performed in the solution phase. Viscosity is affected by a number of parameters such as molecular mass, shape, and size of molecules, concentration, temperature, and intermolecular attractions, that is, ion-ion and ion solvent interactions.

At first PVA solutions in water were prepared with different concentrations (from 1.0 g/dL to 2.5g/dL) and the apparent viscosities of the solutions were measured with the help of Haake make Rheo Stress 6000 viscometer, Thermo Scientific, USA. The temperature was kept constant ($25\pm 2^\circ\text{C}$) for all the measurements. The results are reflected in the plot of apparent viscosity vs. time (Fig.1a) which show that the viscosities of PVA solutions increases with increase in concentration of PVA solution. From these data, relative (η_r) and specific (η_{sp}) viscosities were calculated (Table 1) using equations (i) and (ii).

$$\eta_r = \eta / \eta_0 \dots\dots\dots (i)$$

where, η and η_0 are the apparent viscosities of the PVA solutions and pure solvent (here water) respectively.

$$\eta_{sp} = \eta_r - 1 \dots\dots\dots (ii)$$

The intrinsic viscosity $[\eta]_{int}$ can be obtained by Huggin's equation (iii)

$$[\eta]_{int} = \lim_{c \rightarrow 0} \eta_{sp}/c \dots\dots\dots (iii)$$

The plots of η_{sp}/c against C at fixed temperature is a straight line (Fig. 1b), with the intercept on y-axis showing the value of $[\eta]_{int}$.

The Mark-Houwink equation (iv) was used for estimation of the viscosity average molecular weight (M_v) of PVA

$$[\eta]_{int} = kM_v^a \dots\dots\dots (iv)$$

where, k and a are the Mark-Houwink constants for PVA-water system with values 2.0×10^{-4} dL/g and 0.76 respectively [44 of manuscript]. The M_v was found to be around 16,500 Dalton.

Table 1:

Conc. of PVA (g/dL) (C)	Aparent viscosity (η) (mPas)	$\eta_{sp} = \eta_r - 1$	η_{sp}/C
1.0	1.27	0.4270	0.4270
1.5	1.51	0.6966	0.4644
2.0	1.78	1.000	0.5000
2.5	2.18	1.4494	0.5798

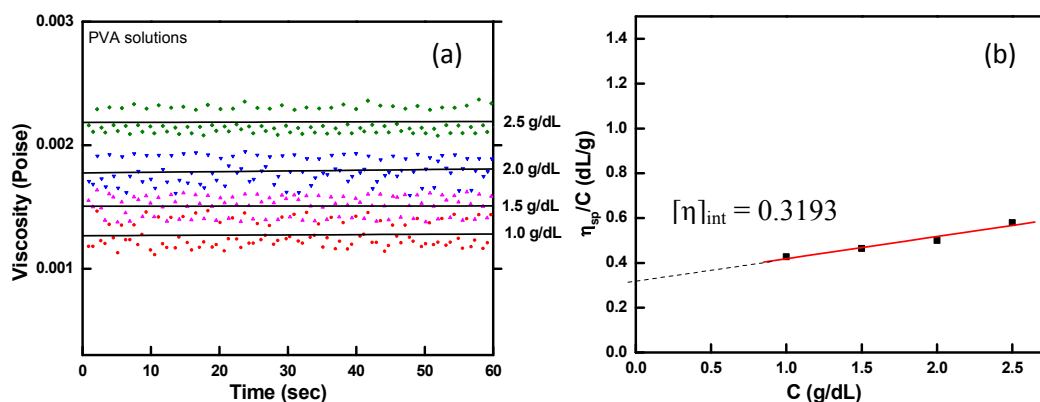


Fig. 1: (a) Plot of viscosity vs time for PVA solutions; (b) plot of η_{sp}/c against C at fixed temperature for the determination of intrinsic viscosity, $[\eta]_{int}$

All the above experiments were repeated for the precursor sol of Cr(III)-Sn(IV) doped In(III) nitrate in similar concentrations of PVA solutions as above. The plot of apparent viscosity vs. time (Fig.2a) show that the viscosities of PVA solutions in presence of salts further increases with increase in concentration of PVA solution than that of pure PVA solutions. In a similar manner as above, relative (η_r) and specific (η_{sp}) and viscosities were calculated (Table 2). The intrinsic ($[\eta]_{int}$) was also determined (Fig. 2b). From the value of $[\eta]_{int}$, the viscosity average molecular weight of PVA was determined in presence of the added salt. This value was found to be around 51,000 Dalton.

Table 2:

Conc. of PVA (g/dL) (C)	Aparent viscosity (η) (mPas)	$\eta_{sp} = \eta_r - 1$	η_{sp}/C
1.0	1.62	0.8202	0.8202
1.5	1.91	1.1461	0.7641
2.0	2.59	1.9101	0.9551
2.5	2.86	2.2135	0.8854

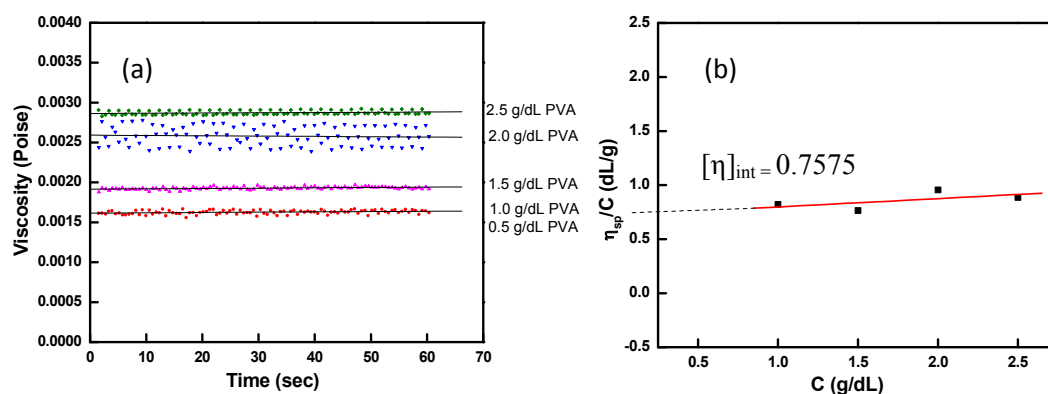


Fig. 2: (a) Plot of viscosity vs time for PVA solutions in presence of salt; (b) plot of η_{sp}/c against C at fixed temperature for the determination of intrinsic viscosity, $[\eta]_{int}$