

# Evaluation of Thermo-Viscosity Parameters of Dextran in Polar and Nonpolar Solvent

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**ABSTRACT:** Some thermo-viscosity parameters like Viscosity-molecular weight constant (K), the short-range parameter, (A) and long-range parameter (B) have been evaluated for the polymer "Dextran" of three different molecular weights ( $\bar{M}_w = 19,500, 75,000, \text{ and } 250,000$ ) in three different solvents like 6 (M) aqueous urea, 2 (M) aqueous glycine, and 50% aqueous glucose at temperatures ranging from 25 to 50°C. The study reveals that the viscosity-molecular weight constant (K) decreases with increase in temperature for polar solvents like aqueous urea and aqueous glycine. The value of "K" increases with the rise in temperature within the range of 25 to 35°C in case of a nonpolar solvent aqueous glucose and then "K" decreases with the increase in temperature within the range of 40 to 50°C for the nonpolar solvent aqueous glucose. The short-range parameter (A) shows the same trend as shown by "K" and the long-range parameter "B" exhibits no definite trend with the variation of temperature. © 2001 John Wiley & Sons, Inc. *J Appl Polym Sci* 81: 440–452, 2001

**Key words:** Viscosity-molecular weight constant (K); short-range parameter (A); long-range parameter (B)

## INTRODUCTION

Thermo-viscosity parameters like viscosity-molecular weight constants (K), short-range parameters (A), and long-range parameters (B) have been evaluated using viscometric measurement technique. Earlier, various researchers<sup>1–4</sup> followed this technique, because of its simplicity, high accuracy, and sensitivity of the instrument used for this purpose.

In our present study we have evaluated K, A, and B of a novel polymer Dextran of three different molecular weights, i.e.,  $\bar{M}_w = 19,500, 75,000, \text{ and } 250,000$  in three different solvents: namely, aqueous urea, aqueous glycine, and aqueous glucose at six different temperatures ranging from 25 to 50°C. K and B can be evaluated by following various graphical procedures given by Stockmayer-Fixman, Fox-Flory, and Kurata-Stockmayer. These graphical procedures involve variation of intrinsic viscosity  $[\eta]$  with molecular weight ( $\bar{M}_w$ ). The viscosity-molecular weight constant (K) is evaluated from ordinate intercepts, and long-range parameter "B" is evaluated from the slope.

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**Table I** Data for Plotting Stockmayer-Fixman, Fox-Flory, and Kurata-Stockmayer's Plot for Dextran of Different Molecular Weights at Different Temperatures in Different Solvents (solvent—6 (M) aqueous urea)

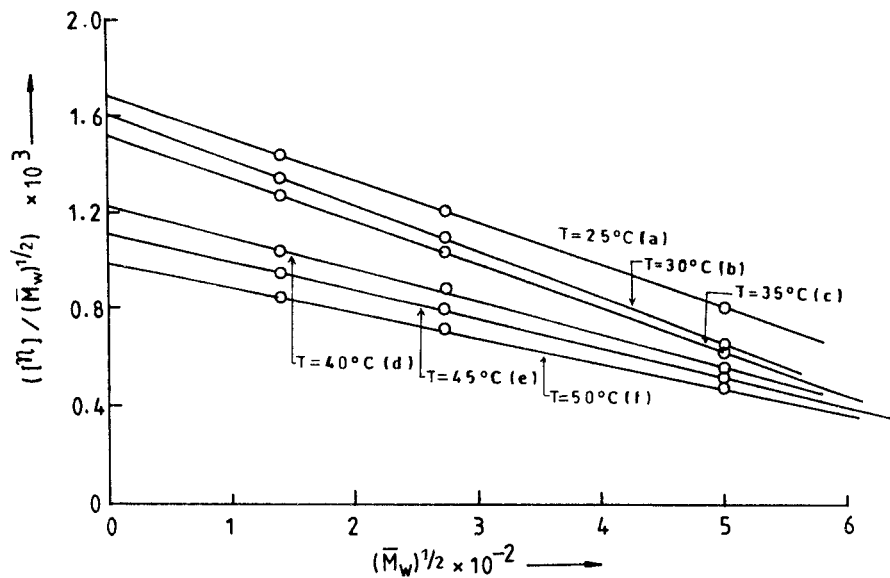
Temperature in °C	$\overline{M}_w$	$(\overline{M}_w)^{1/2}$	$(\overline{M}_w)^{1/3}$	$(\overline{M}_w)^{2/3}$	$[\eta]$	$[\eta]^{1/3}$	$[\eta]^{2/3}$	$\frac{[\eta]}{(\overline{M}_w)^{1/2}} \times 10^3$	$\frac{(\overline{M}_w)}{[\eta]} \times 10^{-5}$	$\frac{[\eta]^{2/3}}{(\overline{M}_w)^{1/3}} \times 10^2$	$\frac{(\overline{M}_w)^{2/3}}{[\eta]^{1/3}} \times 10^{-3}$
25	19,500	139.642	26.916	724.471	0.202	0.587	0.345	1.447	0.965	1.282	1.234
	75,000	273.861	42.172	1778.478	0.329	0.690	0.476	1.201	2.280	1.152	2.578
	250,000	500.000	62.996	3968.496	0.411	0.743	0.552	0.822	6.083	0.876	5.341
30	19,500	139.642	26.916	724.471	0.187	0.572	0.327	1.339	1.043	1.215	1.267
	75,000	273.861	42.172	1778.478	0.313	0.676	0.457	1.103	2.396	1.084	2.631
	250,000	500.000	62.996	3968.496	0.329	0.690	0.476	0.658	7.599	0.756	5.751
35	19,500	139.642	26.916	724.471	0.177	0.561	0.315	1.268	1.102	1.170	1.291
	75,000	273.861	42.172	1778.478	0.293	0.664	0.441	1.040	2.600	1.046	2.678
	250,000	500.000	62.996	3968.496	0.315	0.680	0.462	0.630	7.937	0.733	5.836
40	19,500	139.642	26.916	724.471	0.145	0.525	0.276	1.038	1.345	1.025	1.380
	75,000	273.861	42.172	1778.478	0.269	0.646	0.417	0.882	2.788	0.958	2.753
	250,000	500.000	62.996	3968.496	0.279	0.653	0.426	0.558	8.961	0.676	6.077
45	19,500	139.642	26.916	724.471	0.133	0.510	0.260	0.952	1.466	0.966	1.421
	75,000	273.861	42.172	1778.478	0.244	0.625	0.351	0.801	3.074	0.872	2.846
	250,000	500.000	62.996	3968.496	0.263	0.641	0.411	0.526	9.506	0.652	6.191
50	19,500	139.642	26.916	724.471	0.120	0.493	0.243	0.859	1.625	0.903	1.470
	75,000	273.861	42.172	1778.478	0.228	0.611	0.373	0.713	3.290	0.824	2.911
	250,000	500.000	62.996	3968.496	0.246	0.627	0.393	0.492	10.163	0.624	6.329

**Table II** Data for Plotting Stockmayer-Fixman, Fox-Flory, and Kurata-Stockmayer's Plot for Dextran of Different Molecular Weights at Different Temperatures in Different Solvents(solvent—2 (M) aqueous glycine)

Temperature in °C	$\overline{M}_w$	$(\overline{M}_w)^{1/2}$	$(\overline{M}_w)^{1/3}$	$(\overline{M}_w)^{2/3}$	$[\eta]$	$[\eta]^{1/3}$	$[\eta]^{2/3}$	$\frac{[\eta]}{(\overline{M}_w)^{1/2}} \times 10^3$	$\frac{(\overline{M}_w)}{[\eta]} \times 10^{-5}$	$\frac{[\eta]^{2/3}}{(\overline{M}_w)^{1/3}} \times 10^2$	$\frac{(\overline{M}_w)^{2/3}}{[\eta]^{1/3}} \times 10^{-3}$
25	19,500	139.642	26.916	724.471	0.176	0.560	0.314	1.200	1.108	1.167	1.294
	75,000	273.861	42.172	1778.478	0.304	0.672	0.452	1.110	2.467	1.102	2.647
	250,000	500.000	62.996	3968.496	0.481	0.784	0.615	0.962	5.198	0.976	5.062
30	19,500	139.642	26.916	724.471	0.168	0.552	0.305	1.123	1.161	1.133	1.312
	75,000	273.861	42.172	1778.478	0.280	0.654	0.428	1.022	2.679	1.050	2.719
	250,000	500.000	62.996	3968.496	0.426	0.752	0.566	0.852	5.869	0.898	5.277
35	19,500	139.642	26.916	724.471	0.145	0.525	0.276	1.038	1.345	1.025	1.380
	75,000	273.861	42.172	1778.478	0.243	0.624	0.389	0.887	3.086	0.932	2.850
	250,000	500.000	62.996	3968.496	0.318	0.683	0.466	0.636	7.862	0.740	5.810
40	19,500	139.642	26.916	724.471	0.141	0.520	0.270	1.010	1.383	1.003	1.393
	75,000	273.861	42.172	1778.478	0.235	0.617	0.381	0.858	3.191	0.903	2.882
	250,000	500.000	62.996	3968.496	0.300	0.669	0.448	0.600	8.333	0.711	5.932
45	19,500	139.642	26.916	724.471	0.138	0.517	0.267	0.988	1.413	0.992	1.401
	75,000	273.861	42.172	1778.478	0.227	0.610	0.372	0.829	3.304	0.882	2.916
	250,000	500.000	62.996	3968.496	0.281	0.655	0.429	0.562	8.897	0.681	6.059
50	19,500	139.642	26.916	724.471	0.125	0.500	0.250	0.895	1.560	0.929	1.449
	75,000	273.861	42.172	1778.478	0.210	0.594	0.353	0.751	3.571	0.857	2.994
	250,000	500.000	62.996	3968.496	0.254	0.633	0.401	0.508	9.843	0.637	6.269

Table III Data for Plotting Stockmayer-Fixman, Fox-Flory, and Kurata-Stockmayer's Plot for Dextran of Different Molecular Weights at Different Temperatures in Different Solvents(solvent—50% aqueous glucose)

Temperature in °C	$\overline{M}_w$	$(\overline{M}_w)^{1/2}$	$(\overline{M}_w)^{1/3}$	$(\overline{M}_w)^{2/3}$	$[\eta]$	$[\eta]^{1/3}$	$[\eta]^{2/3}$	$\frac{[\eta]}{(\overline{M}_w)^{1/2}} \times 10^3$	$\frac{(\overline{M}_w)}{[\eta]} \times 10^{-5}$	$\frac{[\eta]^{2/3}}{(\overline{M}_w)^{1/3}} \times 10^2$	$\frac{(\overline{M}_w)^{2/3}}{[\eta]^{1/3}} \times 10^{-3}$
25	19,500	139.642	26.916	724.471	0.411	0.743	0.552	2.943	0.474	2.051	0.975
	75,000	273.861	42.172	1778.478	0.463	0.774	0.599	2.220	1.620	1.692	2.298
	250,000	500.000	62.996	3968.496	0.520	0.804	0.646	1.040	4.808	1.025	4.936
30	19,500	139.642	26.916	724.471	0.477	0.781	0.610	3.416	0.409	2.266	0.928
	75,000	273.861	42.172	1778.478	0.532	0.810	0.656	2.601	1.410	1.891	2.196
	250,000	500.000	62.996	3968.496	0.598	0.842	0.709	1.196	4.181	1.125	4.713
35	19,500	139.642	26.916	724.471	0.563	0.826	0.682	4.032	0.346	2.534	0.877
	75,000	273.861	42.172	1778.478	0.616	0.851	0.724	3.339	1.218	2.104	2.090
	250,000	500.000	62.996	3968.496	0.668	0.874	0.764	1.336	3.743	1.213	4.541
40	19,500	139.642	26.916	724.471	0.257	0.636	0.404	1.840	0.759	1.501	1.139
	75,000	273.861	42.172	1778.478	0.279	0.653	0.426	1.381	2.688	1.240	2.724
	250,000	500.000	62.996	3968.496	0.303	0.672	0.452	0.606	8.251	0.718	5.906
45	19,500	139.642	26.916	724.471	0.178	0.563	0.317	1.275	1.096	1.178	1.287
	75,000	273.861	42.172	1778.478	0.199	0.584	0.341	0.972	3.769	0.981	3.045
	250,000	500.000	62.996	3968.496	0.219	0.603	0.364	0.438	11.416	0.578	6.581
50	19,500	139.642	26.916	724.471	0.143	0.523	0.274	1.024	1.364	1.018	1.385
	75,000	273.861	42.172	1778.478	0.158	0.541	0.293	0.757	4.747	0.831	3.287
	250,000	500.000	62.996	3968.496	0.561	0.561	0.315	0.357	14.124	0.500	7.074



**Figure 1** Stockmayer-Fixman's plot for Dextran of different molecular weight in 6 (M) Urea at different temperature.

**THEORY**

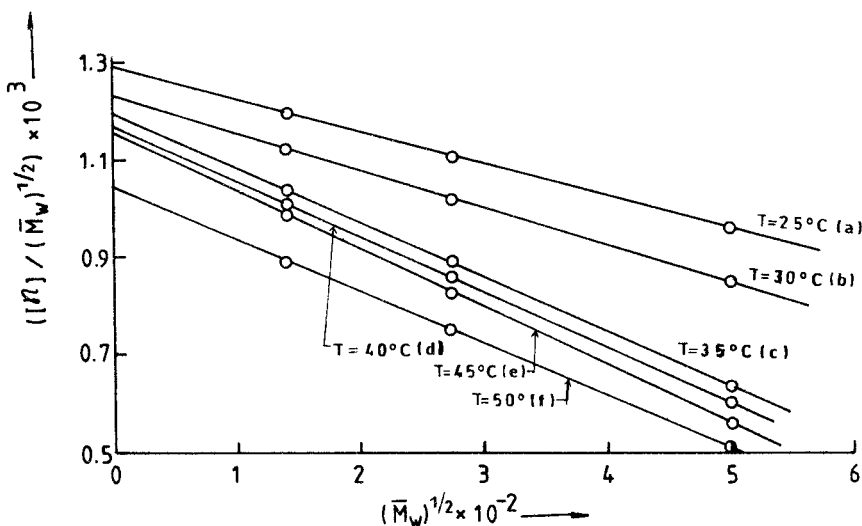
The Stockmayer-Fixman<sup>5</sup> equation involving variation of intrinsic viscosity  $[\eta]$  with molecular weight  $\bar{M}_w$  is given by,

$$[\eta] = K (\bar{M}_w)^{1/2} + 0.51\phi_o B \bar{M}_w \quad (1)$$

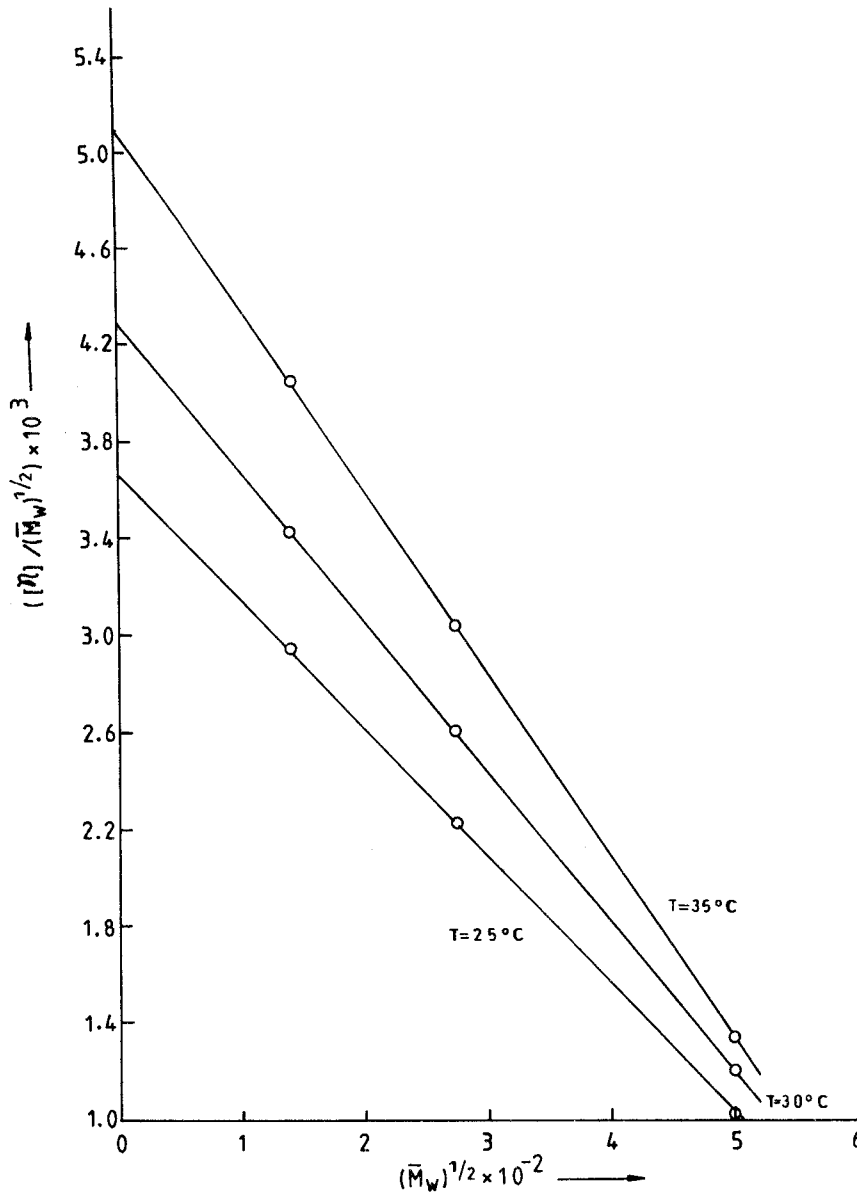
where B is the long-range parameter and  $\phi_o$  is the universal constant.

To determine the viscosity-molecular weight constant (K) and long-range parameter (B) of a polymer molecule in any solvent at any temperature, another relationship is given by Fox-Flory,<sup>6</sup> which is represented as

$$\frac{[\eta]^{2/3}}{(\bar{M}_w)^{1/3}} = K^{2/3} + 0.857 K^{2/3} \phi_o B \frac{\bar{M}_w}{[\eta]} \quad (2)$$



**Figure 2** Stockmayer-Fixman's plot for Dextran of different molecular weight in 2 (M) Glycine at different temperature.



**Figure 3** (a) Stockmayer-Fixman's plot for Dextran of different molecular weight in 50% Glucose at different temperature.

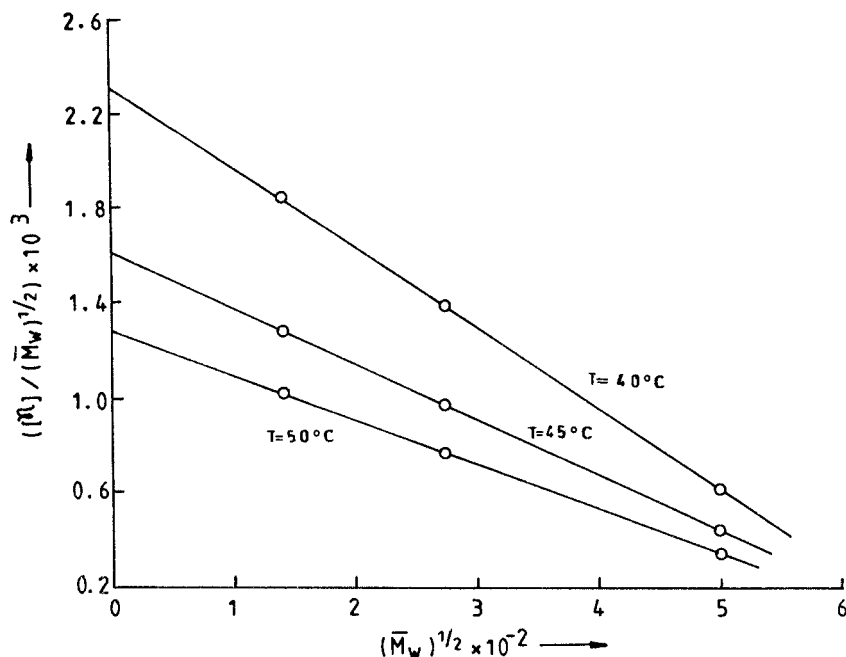
Kurata and Stockmayer<sup>7</sup> had also given the following relation for determination of "K" and "B," which is represented as

$$\frac{[\eta]^{2/3}}{(\bar{M}_w)^{1/3}} = K^{2/3} + 0.363\phi_0 B g (\alpha_n)[(\bar{M}_w)^{2/3}[\eta]^{-1/3}] \quad (3)$$

where  $\alpha_n$  is the volume expansion factor and  $g$  ( $\alpha_n$ ) is the coefficient dependent on  $\alpha_n$ .

The short range parameter "A" of the polymer depends upon the solvent used as well as on the temperature of the polymer solution. Yamakawa<sup>8</sup> had given the following relation for determination of short-range parameter "A," which is represented as

$$A = \left(\frac{K}{\phi_0}\right)^{1/3} \quad (4)$$



**Figure 3** (b) Stockmayer-Fixman's plot for Dextran of different molecular weight in 50% Glucose at different temperature.

**Table IV** Values of "K" of Dextran in Different Solvents at Different Temperatures from Various Plots (Solvent—6 (M) Aqueous Urea)

Temperature in °C	The Value of K ( $\times 10^3$ ) from Various Plots			Mean Value of K $\times 10^3$
	Stockmayer- Fixman	Fox-Flory	Kurata- Stockmayer	
25	166.024	158.602	149.079	157.902
30	161.162	146.857	138.081	148.700
35	153.223	138.081	131.453	140.919
40	123.056	113.017	108.054	114.709
45	112.116	103.470	099.251	104.946
50	099.037	092.595	089.686	093.773

**Table V** Solvent—2 (M) Aqueous Glycine

Temperature in °C	The Value of K ( $\times 10^3$ ) from Various Plots			Mean Value of K $\times 10^3$
	Stockmayer- Fixman	Fox-Flory	Kurata- Stockmayer	
25	129.000	126.555	135.583	130.379
30	123.516	121.719	133.100	126.078
35	119.802	106.825	116.946	114.524
40	117.313	103.015	113.017	111.115
45	115.945	100.751	112.237	109.644
50	104.508	092.595	102.258	099.787

**Table VI Solvent—50% Aqueous Glucose**

Temperature in °C	The Value of K ( $\times 10^3$ ) from Various Plots			Mean Value of K $\times 10^3$
	Stockmayer- Fixman	Fox-Flory	Kurata- Stockmayer	
25	367.204	301.606	348.812	339.207
30	430.571	345.973	407.202	394.582
35	512.008	409.600	481.135	467.581
40	231.812	190.644	219.213	213.890
45	161.736	135.583	152.519	149.946
50	128.044	110.488	123.324	120.619

**Table VII Values of Short-Range Parameter (A) and Long-Range Parameter (B) of Dextran in Different Solvents at Different Temperatures (Solvent—6 (M) Aqueous Urea)**

Temperature in °C	A $\times 10^8$ in cm from				B $\times 10^{28}$ in cm <sup>3</sup> from			
	Stockmayer- Fixman Plot	Fox- Flory Plot	Kurata- Stockmayer Plot	Mean A $\times 10^8$ in cm	Stockmayer- Fixman Plot	Fox- Flory Plot	Kurata- Stockmayer Plot	Mean B $\times 10^{28}$ in cm <sup>3</sup>
25	3.881	3.822	3.744	3.816	12.127	2.356	15.630	10.038
30	3.843	3.726	3.650	3.740	13.151	2.229	15.963	10.448
35	3.779	3.650	3.590	3.673	12.466	2.121	12.955	9.181
40	3.512	3.414	3.363	3.430	9.062	1.745	6.229	5.679
45	3.405	3.315	3.269	3.330	8.497	1.606	4.699	4.934
50	3.267	3.195	3.161	3.208	7.077	1.471	3.125	3.891

**Table VIII Values of Short-Range Parameter (A) and Long-Range Parameter (B) of Dextran in Different Solvents at Different Temperatures (Solvent—2 (M) Aqueous Glycine)**

Temperature in °C	A $\times 10^8$ in cm from				B $\times 10^{28}$ in cm <sup>3</sup> from			
	Stockmayer- Fixman Plot	Fox- Flory Plot	Kurata- Stockmayer Plot	Mean A $\times 10^8$ in cm	Stockmayer- Fixman Plot	Fox- Flory Plot	Kurata- Stockmayer Plot	Mean B $\times 10^{28}$ in cm <sup>3</sup>
25	3.568	3.545	3.628	3.580	4.603	1.512	4.275	3.463
30	3.517	3.500	3.605	3.541	5.393	1.730	4.867	3.997
35	3.481	3.351	3.453	3.428	6.639	1.691	4.048	4.126
40	3.457	3.310	3.414	3.394	7.671	1.772	3.819	4.421
45	3.443	3.286	3.406	3.378	8.147	1.717	3.729	4.531
50	3.326	3.195	3.302	3.274	7.480	1.514	2.735	3.910

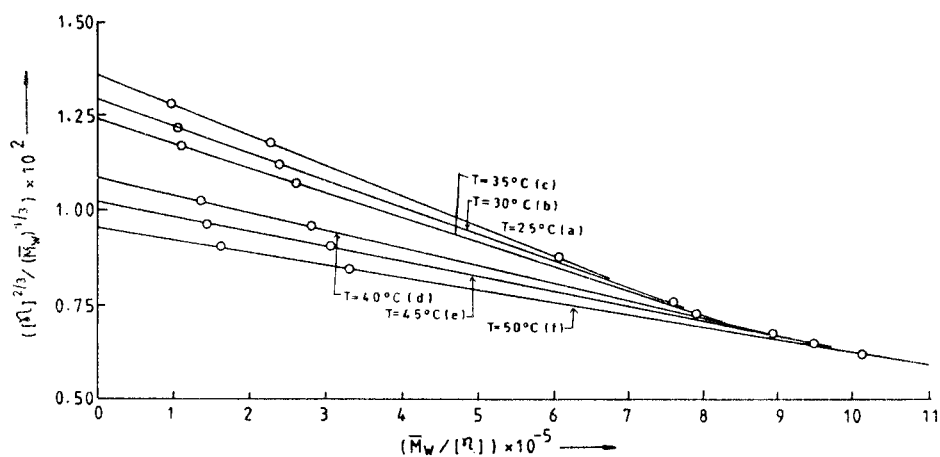
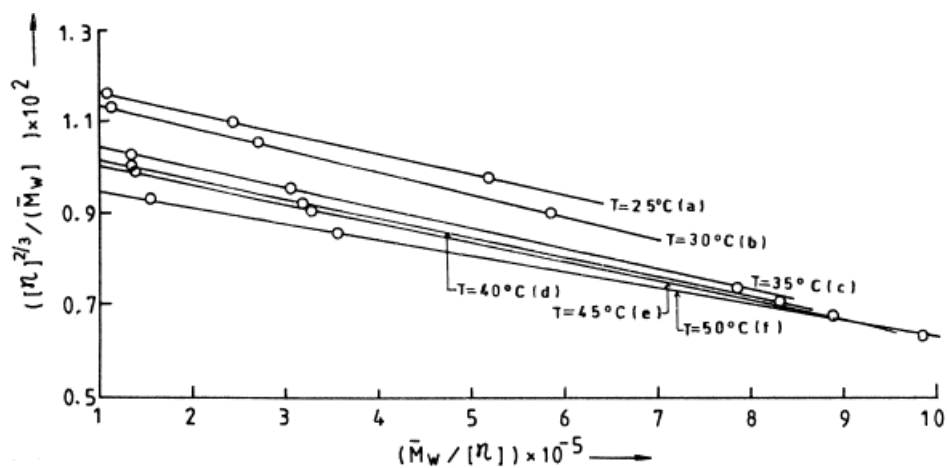
where K is the thermo-viscosity parameter, which depends upon the nature of the solvent and temperature of the polymer solution, and  $\phi_0$  is the

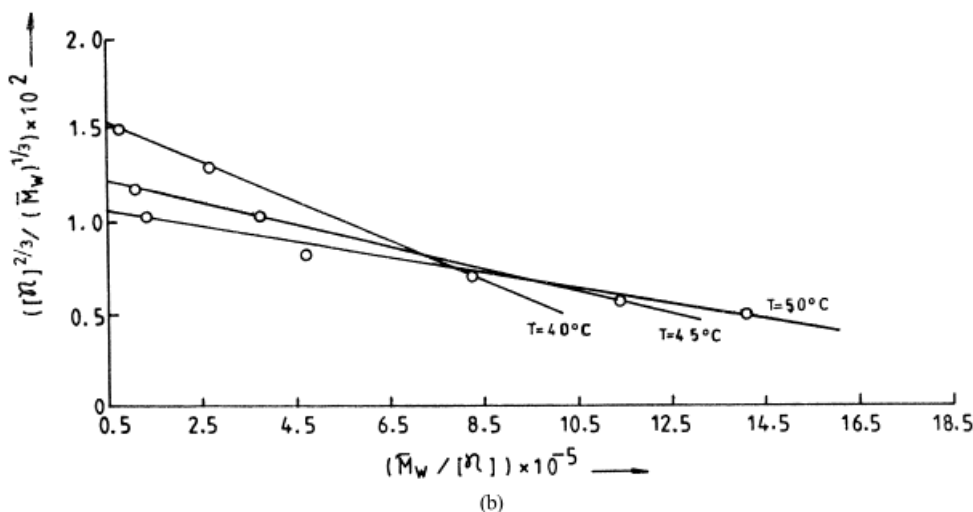
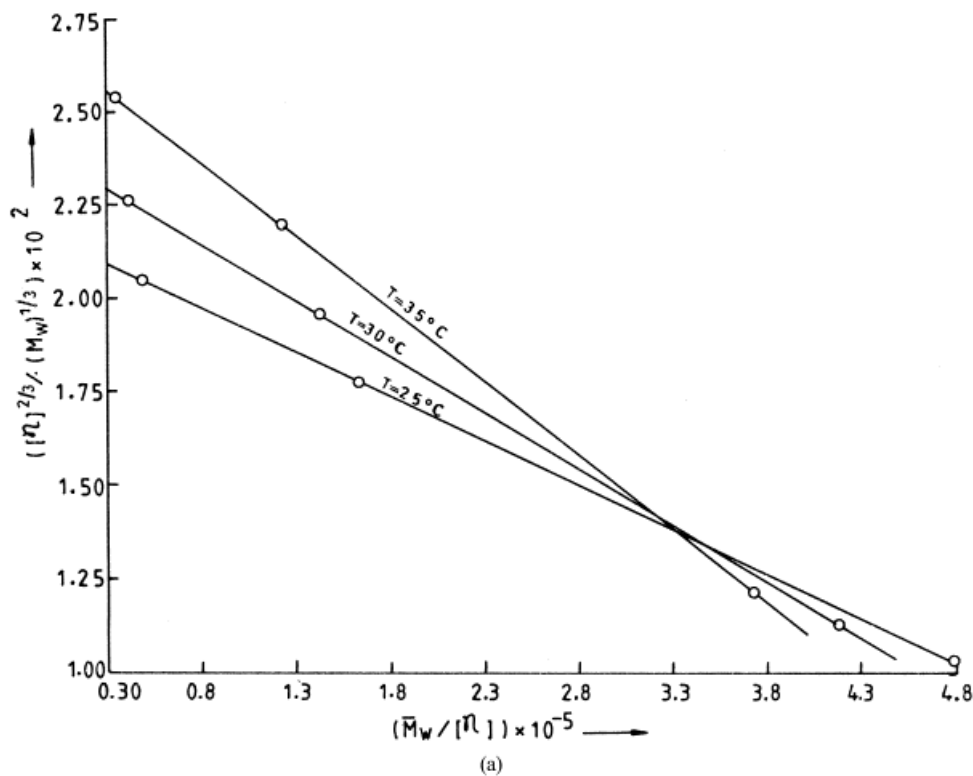
universal constant, which does not depend on polymer type solvent as well as temperature ( $\phi_0 = 2.84 \times 10^{21}$ ).



**Table IX** Values of Short-Range Parameter (A) and Long-Range Parameter (B) of Dextran in Different Solvents at Different Temperatures (Solvent—50% Aqueous Glucose)

Temperature in °C	A × 10 <sup>8</sup> in cm from				B × 10 <sup>28</sup> in cm <sup>3</sup> from			
	Stockmayer- Fixman Plot	Fox- Flory Plot	Kurata- Stockmayer Plot	Mean A × 10 <sup>8</sup> in cm	Stockmayer- Fixman Plot	Fox- Flory Plot	Kurata- Stockmayer Plot	Mean B × 10 <sup>28</sup> in cm <sup>3</sup>
25	5.057	4.736	4.971	4.921	37.078	47.047	32.281	38.802
30	5.332	4.957	5.234	5.174	41.918	54.422	46.226	47.522
35	5.649	5.244	5.533	5.475	50.873	60.915	80.470	64.086
40	4.338	4.064	4.258	4.220	23.474	27.753	27.543	26.257
45	3.847	3.628	3.773	3.749	15.933	19.455	24.308	19.899
50	3.559	3.388	3.515	3.487	12.945	15.791	10.127	12.954

**Figure 4** Fox-Flory's plot for Dextran of different molecular weight in 6 (M) Urea at different temperature.**Figure 5** Fox-Flory's plot for Dextran of different molecular weight in 2 (M) Glycine at different temperature.



**Figure 6** (a) and (b) Fox-Flory's plot for Dextran of different molecular weight in 50% Glucose at different temperature.

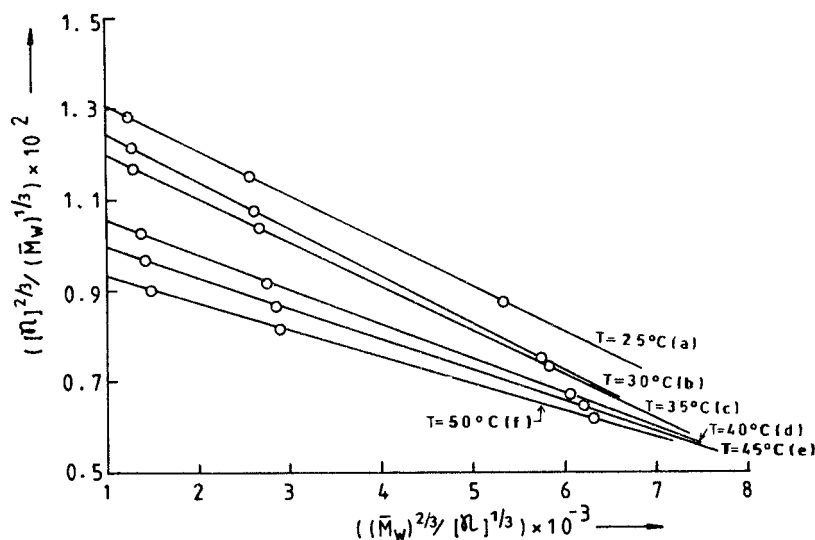
## EXPERIMENTAL

### Materials

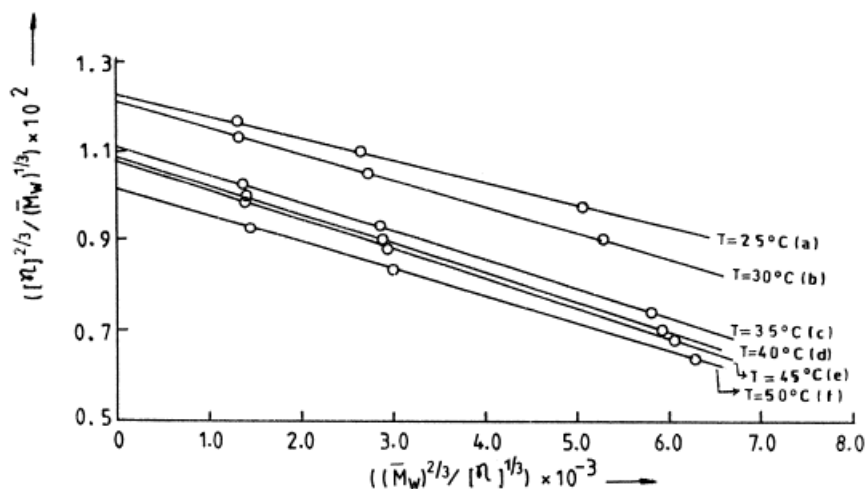
#### Polymer

Dextran ( $\bar{M}_w = 19,500, 75,000, \text{ and } 250,000$ ) were a gift sample from Dextran Products Limited, Canada. Dextran is the collective name of a large class of extracellular bacterial polysaccha-

rides composed almost exclusively of the monomeric unit  $\alpha$ -D-glucopyranose linked mainly by 1,6 bonds. Dextrans are synthesized from sucrose by certain species of the family such as streptococcus and lactobacillus. Dextrans develop naturally in sucrose-containing solutions that have become inoculated with dextran producing bacteria from air, plants, or soil. It is the only polysaccharide that is water soluble.



**Figure 7** Kurata-Stockmayer's plot for Dextran of different molecular weight in 6 (*M*) Urea at different temperature.



**Figure 8** Kurata-Stockmayer's plot for Dextran of different molecular weight in 2 (*M*) Glycine at different temperature.

### Solvent Systems

The solvent systems such as aqueous solutions of urea, glycine, and glucose are BDH (AR) grade and used as such throughout the experiment.

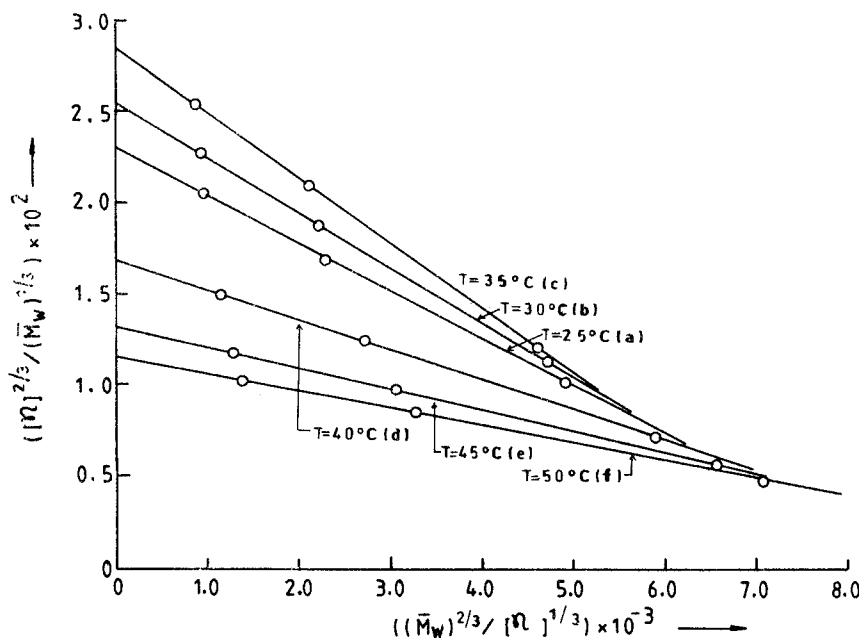
A freshly prepared solution of (1 wt %) the samples were prepared in solvents like 6 (*M*) aqueous urea, 2 (*M*) aqueous glycine, and 50% aqueous glucose.

### Method

We used the viscometric technique<sup>9</sup> to measure the flow time of the pure solvent solution as well as polymer-solvent solution with the help of an Ub-

belohde type suspended level dilution viscometer. Aqueous solutions of 6 (*M*) urea, 2 (*M*) glycine, and 50% glucose were prepared, and their efflux time were measured at six different temperatures: ranging from 25 to 50°C. One percent dextran solutions were prepared in the above-mentioned solvents, and their efflux times were measured in the above temperature range. The concentration (*c*) of the polymer solution was gradually reduced by adding an installment of 2 mL solvent solution, and the flow time was measured in each of the concentration at the above temperature range.

The relative viscosity ( $\eta_{rel}$ ) and specific viscosity ( $\eta_{sp}$ ) were calculated. Huggins,<sup>10</sup> Kraemer,<sup>11</sup>



**Figure 9** Kurata-Stockmayer's plot for Dextran of different molecular weight in 50% Glucose at different temperature.

and Schulz-Blaschke's<sup>12</sup> plots were drawn, and extrapolating these plots for infinite dilution  $c = 0$  the intrinsic viscosity  $[\eta]$ <sup>13</sup> was calculated. Finally using Stockmayer-Fixman, Fox-Flory, and Kurata-Stockmayer's plot the viscosity molecular weight constant (K), short-range parameter (A), and long-range parameter (B) were evaluated.

## RESULTS AND DISCUSSION

Determination of viscosity-molecular weight constant (K) and long-range parameter (B) are from the following.

### Stockmayer-Fixman's Plot

The Stockmayer-Fixman eq. (1) can be written in more convenient form as

$$\frac{[\eta]}{(\bar{M}_w)^{1/2}} = K + 0.51\phi_o B (\bar{M}_w)^{1/2} \quad (5)$$

The graph is plotted by taking  $[\eta]/(\bar{M}_w)^{1/2}$  along the Y-axis and  $(\bar{M}_w)^{1/2}$  along the X-axis, which is a straight line.

The ordinate intercept of the curve gives the value of "K," and the slope of the curve gives the

value of  $0.51\phi_o B$ . So dividing the slope of the curve by  $0.51\phi_o$ , provides us the value of "B." The data required to plot the Stockmayer-Fixman's graph are shown in Tables I to III.

The curve is repeated for the three solvents as well as for six different temperatures, which are shown in Figures 1 to 3. The values of "K" are represented in Tables IV to VI, and the values of "B" are represented in Table VII to IX.

From these plots we find that "K" decreases with the increases in temperature in polar solvents like 6 (M) aqueous urea and 2 (M) aqueous glycine, where as K increases with the increase in temperature for the nonpolar solvent aqueous glucose in the lower temperature range, i.e., from 25 to 35°C. The values of K show the same trend in aqueous glucose in the higher temperature range, i.e., from 40 to 50°C, as shown by aqueous urea and aqueous glycine. This diametrically opposite trend in the values of "K" of Dextran in the solvent glucose is of the same trend as that the variation of intrinsic viscosity  $[\eta]$  with temperature.<sup>14</sup> This is due to the fact that in the lower temperature range the solvent glucose forms a gel with the solute Dextran and this gel becomes thicker and thicker with the rise in temperature; hence, the viscosity increases, but after a certain temperature (38°C) this trend is reversed, because with the rise in temperature more and more

polymer chains of Dextran are broken; hence, the viscosity decreases. Thus, we find that the value of  $K$  is the least in the case of glycine, and maximum for glucose.

From these we find that "B" is the least in the case of glycine and maximum for glucose. No particular trend is observed in the variation of "B" with the temperature for a particular solvent. This is due to the fact that the relative variation of intrinsic viscosity  $[\eta]$  with temperature is not uniform for a particular solvent.

### Fox-Flory's Plot

The Fox-Flory<sup>6</sup> equation used for determination of viscosity-molecular weight constant "K" and long-range parameter "B" is represented by the equation (2).

We plot the graph by taking  $([\eta]^{2/3}/(\bar{M}_w)^{1/3})$  along the Y-axis and  $(\bar{M}_w/[\eta])$  along the X-axis, then the ordinate intercept, provides the value of  $K^{2/3}$  from which "K" can be calculated. Dividing the slope of the curve by "0.857  $K^{2/3} \phi_o$ " provides us the value of B. The above curve is repeated for a particular solvent at six different temperatures as well as for the three different solvents we had chosen. These curves are shown in Figures 4 to 6. The values of "K" and "B" are represented in Tables IV to VI and VII to IX, respectively.

From the above curves we find that the values of "K" and "B" in different solvents at different temperatures show the same trend as shown by "K," which was obtained from the Stockmayer-Fixman's plot.

### Kurata-Stockmayer's Plot

Using the Kurata-Stockmayer's<sup>7</sup> eq. (3) we plot a graph by taking  $([\eta]^{2/3}/(\bar{M}_w)^{1/3})$  along the Y-axis, and  $(\bar{M}_w^{2/3}/[\eta]^{1/3})$  along the X-axis, then the ordinate intercept provides the value of  $K^{2/3}$  from which the value of K can be calculated, whereas dividing the slope of the curve by  $0.363 \phi_o g(\alpha_n)$ , provides us the value of B. This curve is repeated for all the three solvents at six different temperatures i.e., 25, 30, 35, 40, 45, and 50°C. These curves are shown in Figures 7 to 9. The values of "K" and "B" are represented in Tables IV to VI and VII to IX, respectively.

The values of "K" and "B" in different solvents at different temperatures obtained by the Kurata-Stockmayer's plot show the same trend as obtained by the Stockmayer-Fixman and Fox-Flory's Plot.

Finally, the mean values of "K" and "B" for a particular solvent at a particular temperature are

calculated and represented in Table IV to VI and VII to IX, respectively.

### Evaluation of Short-Range Parameter "A"

The short-range parameter "A" can be calculated using the relation given by Yamakawa<sup>8</sup> [i.e., eq. (4)].

The values of "K" obtained from three different plots for a particular solvent at a particular temperature used in eq. (4) to evaluate A, which are represented in Tables VII to IX.

From our present study we find that the short-range parameter "A" is the least in the case of aqueous glycine, and maximum for aqueous glucose among the three solvents we have chosen. The short-range parameter show the same trend as shown by K, i.e., "A" decreases with the increase in temperature for the polar solvents 6 (M) aqueous urea, 2 (M) aqueous glycine, and in the higher temperature range (40°C to 50°C) for non-polar solvent aqueous glucose. Whereas in the lower temperature range (25 to 35°C) the value of "A" increases with the increase in temperature for the nonpolar solvent aqueous glucose.

The mean values of "A" for a particular solvent at a particular temperature are calculated, which are represented in Tables VII to IX.

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