Rheological Study of Guar Gum

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A rheological study of guar gum indicated a non-Newtonian, pseudoplastic behaviour of its solutions. When the data was treated mathematically by the modified Newton's law, $F^N = \eta' G$, the exponential constant N was found to increase with increasing concentration of gum. The viscosity of the solutions remained fairly constant in the pH range from 1.5 to 10.5.

Guar gum (GG), also known as guaran or jaguar gum, is a gum obtained from the ground endosperms of *Cyamopsis tetragonolobus* (Linné) Taub. (Fam. Leguminosae). It consists chiefly of a high molecular weight hydrocolloidal polysaccharide, composed of galactan and mannan units combined through glycosidic linkages, which may be described chemically as a galactomannan[1]. GG occurs as an odourless or nearly odourless, white to yellowish-white powder with a bland taste and molecular weight of approximately 2,20,000[2]. It is dispersible in hot and cold water forming a colloidal solution[3]. The rheological behaviour of commercial sample of guar gum was studied and the results are reported in the present communication.

Dealca P-5000 (a high viscosity grade of guar gum) was received as a gift sample from The Prince Chemical Works, Mumbai. Hydrochloric acid and sodium hydroxide used were of A.R. grade and procured from S. D. Fine Chemicals, Mumbai. A 1% w/v solution of GG in distilled water was prepared in the following manner. A weighed quantity of GG was sprinkled in parts onto distilled water, corresponding to 3/4th of the final volume of solution, while being stirred using an overhead stirrer. The stirring was continued for 1h after the addition of GG was completed. The solution was kept aside for 24 h to allow the GG to hydrate and swell completely to its equilibrium value. The volume was made up with distilled water to produce a 1% w/v solution of GG and stirred for an additional 20 min to achieve a uniform solution.

GG solutions having concentrations of 0.8% w/v, 0.6% w/v, 0.4% w/v and 0.2% w/v were prepared by suitably diluting the 1% w/v solution of GG. Diluted solutions were stirred for 20 min to achieve a uniform product and a period of 10 h was allowed to elapse before determining their viscosity in order to allow the systems to stabilize and attain their equilibrium viscosity.

The viscosity of the GG solutions was measured with a Brookefield Synchro-Lectric Viscometer, Model RVT (Brookefield Engineering Laboratories, Inc., U.S.A.) at 25° in the range of 0.5 to 100 rpm. The pH of the 0.5% w/v GG solution was first adjusted to 1.5 using dilute hydrochloric acid and the viscosity was measured as described earlier. The pH of the GG solution was then raised to 2 using 20% w/v sodium hydroxide solution, the solution was allowed to stabilize for 30 min and its viscosity was measured. In a similar manner, the viscosity of the GG solution was measured at pH values of 3, 4, 5, 6, 7, 8, 9, 10.5 and 12, with a stabilization period of 30 min between the measurement at two consecutive pH values.

The 1% w/v solution of GG in water was translucent and had a thick gel-like consistency. The 0.8% w/v and 0.6% w/v solutions of GG were also translucent but had a thinner consistency. The 0.4% w/v and 0.2% w/v solutions appeared like a fine (colloidal) dispersion.

It is evident from fig. 1 that GG exhibits a non-Newtonian, pseudoplastic rheological behaviour at higher concentrations (1.0% w/v, 0.8%w/v and 0.6% w/v). At 0.4% w/v and 0.2% w/v concentration, GG solutions showed a less pseudoplastic response. This is in keeping with the observation in literature[4] that the viscosity of

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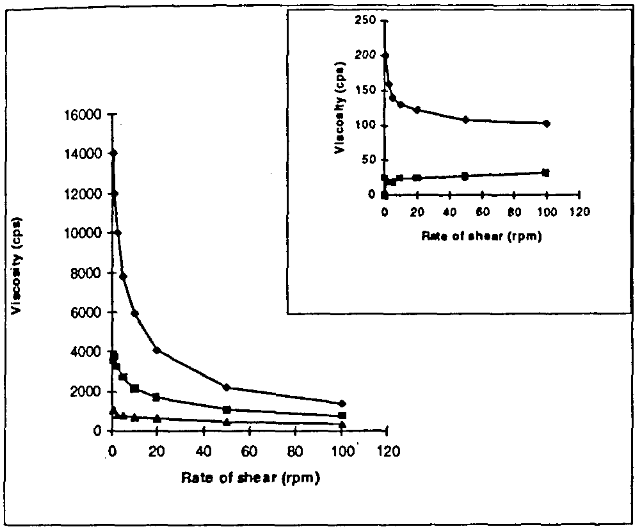

Fig. 1: Viscosity of GG solutions at different shear rates

Rheology of GG solutions was studied at different concentrations such as 1% w/v (◆), 0.8% w/v (◻), 0.6% w/v (▲), [Inset : 0.4% w/v (◆), 0.2%w/v (◻)]

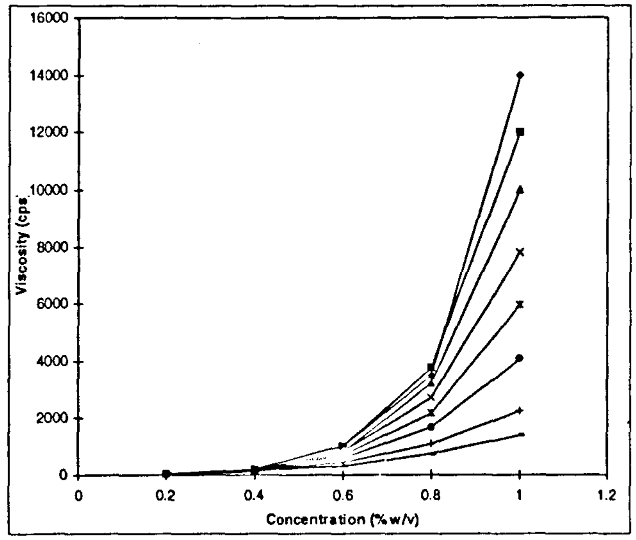

Fig. 2: Exponential relationship between viscosity and concentration of GG solutions of different concentrations

Viscosity of GG solution at different concentrations was measured at shear rates of 0.5 rpm (◆), 1 rpm (◻), 2.5 rpm (▲), 5 rpm (X), 10 rpm (☆), 20 rpm (O), 50 rpm (+) and 100 rpm (-).

0.3% GG solution changes only slightly with increasing shear. GG solutions did not exhibit any significant thixotropy, as viscosity of GG solution of a given concentration on the upcurve and downcurve were almost the same. When the data was represented as a plot of viscosity v/s concentration of the solution, an exponential relationship ($r > 0.9$) was observed between the concentration of GG solutions and their corresponding viscosities, as is evident from fig. 2.

The viscosity data of the GG solutions was also analysed by the modified Newton's law[5]

$$F^N = \eta' G$$

where, F = shearing stress, G = shearing rate, η' = apparent viscosity (unit less) and N = Constant, which depends on the substance and its concentration.

Table 1 shows values of N and apparent viscosity of GG solutions having different concentrations. The value of the exponential constant, N, is considered to be an index which describes the behaviour of the liquid. When N=1, the flow is Newtonian, when greater than 1, it is pseudoplastic, and when less than 1, the flow is dilatant[5]. The value of N for all concentrations was found to be greater than 1, indicating that they behave as pseudoplastic systems, and the value of N was found to increase with an increase in concentration of the GG solutons. The relationship between N and concentration of GG (at 1.0% w/v and 0.6% w/v) was a zero order

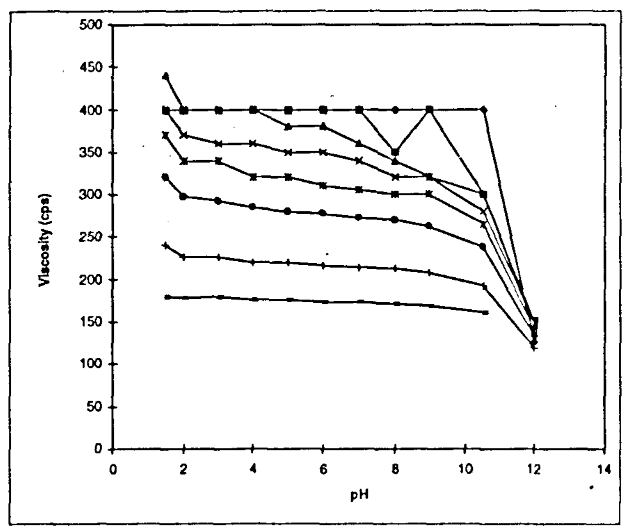

Fig. 3: Effect of pH on the viscosity of a 0.5% w/v GG solution

Viscosity of a 0.5% w/v guar gum solution was measured at different pH levels by subjecting the GG solution to shear rates of 0.5 rpm (◆), 1 rpm (◻), 2.5 rpm (▲), 5 rpm (X), 10 rpm (✳), 20 rpm (O), 50 rpm (+) and 100 rpm (-).

TABLE 1: VALUES OF EXPONENTIAL CONSTANT, N AND APPARENT VISCOSITY OF THE GUAR GUM SOLUTIONS

Concentration (% w/v)	Exponential constant (N)	Apparent viscosity (η')
1	1.4077	122.4052
0.8	1.2242	16.47404
0.6	1.0607	2.591194

function; whereas, a first order relation was found to exist between apparent viscosity and concentration of guar gum (1.0% w/v, 0.8% w/v and 0.6% w/v), complying with the equation $\eta = e^{KC+b}$, where the values of the constants K and b obtained were 9.638 and -4.857, respectively.

GG showed a non-Newtonain pseudoplastic rheological behaviour at all the pH's studied. Fig. 3 shows the effect of pH on viscosity of the GG solutions at different shear rates. It can be seen that from pH 1.5 to pH 10.5, the viscosity remains nearly constant at a given shear rate. At pH 12, the viscosity of the GG solution decreases. Thus, solutions of guar gum exhibited non-Newtonian, pseudoplastic behaviour at all pHs. The viscosity of the solutions was found to remain fairly constant from pH 1.5 to 10.5.

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Spectrophotometric Estimation of Total Alkaloids from *Cinchona officinalis* Stem Bark and Marketed Formulations Containing *Cinchona*

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The alkaloids of stem bark of *Cinchona officinalis* and the marketed formulations containing the stem bark of *Cinchona* were estimated by spectrophotometric method using tropaeolin'OO' for the formation of colour complex. In *Cinchona* stem bark, the alkaloids are bound to tannins. The method adopted for the extraction of alkaloids from the samples has the advantage of extraction of mainly the alkaloids and not the other interfering substances like tannins. The method of analysis was found to be sensitive, precise and accurate and it can be adopted for routine quality control purposes.

Cinchona species (Family:Rubiaceae) are known for antimalarial activity and other potential therapeutic values of the stem bark. Stem bark of *Cinchona* species is included in many herbal, Ayurvedic and Homeopathic formulations. The active principles are quinoline alkaloids, the important ones being quinine, quinidine, cinchonine and cinchonidine. Quinine and its analogues are mainly used as antimalarials for the treatment of *Plasmodium falciparum* infections. Quinidine is known for its antiarrythmic properties[1]. In the present paper, the total

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