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Study on Rheological Behavior of Konjac Glucomannan

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Abstract

Konjac glucomannan (KGM) gum belongs to pseudoplastic fluid. Remarkable non-linear change tendencies of shear rheological behavior of KGM were detected through analysis of the correlation of viscosity (η)-shear rates and shear stress- shear rates respectively. The result shows that the sample concentration, sheer rate and temperature has great influence to its rheological property, and its shear rheological curves conformed to the Power Law ($\tau = KD^n$). When the concentration belows 0.55%, the hydrosol behaves approximate Newtonian fluid, and at higher concentration, it behaves pseudoplastically. When temperature changes from 0 to 85 ℃, the viscosity declines remarkably.

Keywords: Konjac Glucomannan; Rheological behavior; Non-linear change tendencies; Concentration effect; Temperature effect

1 Introduction

Konjac (Amorphallus Konjac K. Koch) is an araceae herbaceous perennial, the main component Konjac glucomannan (KGM) is a D-glucose and D-mannose ratio of 1:1.6 according to β-1,4 glycosidic linkage of complex polysaccharides[1], high viscosity of water-soluble adhesive, with a typical false plasticity[2], its excellent thickening, blend, gel, film, and biological degradation performance has been widely used in food, drilling and biomedical fields[3-5]. single of KGM [2,3], blending[6]and gel [7] rheological studies have been widely carried, wided the application areas, put forward higher requirements about the quality evaluation criteria for KGM.

Rheology performance of KGM affect the amount of product processing, quality and production efficiency, especially as stabilizers, thickeners impact significant, such as storage stability. The quality of KGM could be evaluated by viscosity η, coefficient K and flow index n. This paper examines rheological behavior of KGM to use of rheometer.

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2 Materials and equipment

Konjac gum, purchased from Shanghai BLG; Haake rheometer, TYP :001-1407, W. Germany; Dynamic rheometer, AR500, American TA Company; DAWN/ HELEOS static laser light scattering instrument, the United States Huai Yate technology company.

3 Methods

3.1 Purification and determination of molecular weight on KGM

Reference to L.B[8] prepared KGM. With 0.2mol/L phosphate buffer prepared 1.0×10^{-3}g/mL KGM. Conditions of laser light scattering analysis: Shodex-G805 gel column, Opticlab rEX detector, wavelength 658nm, mobile phase 0.2mol/L phosphate buffer, flow rate 1.0mL/min, used Astra software.

3.2 Static rheological analysis

The measurement of KGM was dispersed in distilled water, stirring at 25℃, full swelling, namely 1.00% (w/w) and set the concentration of KGM sol, Haake rheometer set temperature and speed, analysis shear rate on the impacts of apparent viscosity (η). Each experiment was repeated for three times, find the error within 2% to seek to its average.

3.3 Dynamic rheological analysis

Preparation of the concentration on KGM sol, used of AR500 rheometer in vibration mode by the temperature and frequency scanning determined viscosity of solution changes with temperature and frequency of flow curve. Temperature range 10~100 ℃, the frequency range of 0~120rad/s, plate diameter of 4cm, flat gap 1mm.

4 Results and Discussion

4.1 Molecular weight and distribution

Molecular weight is an important indicators to determine the rheological properties.Fig.1 shows the molecular weight (Mw) of KGM was 1.34×10^6, molecular weight distribution approximates a normal distribution, polydispersity (Mw/Mn) was 1.21, showed that the relative concentration of molecular weight distribution on KGM, was relatively homogeneous polysaccharide.

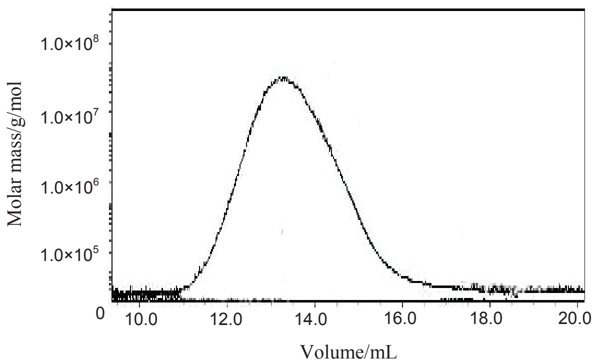

Fig.1. GPC spectrum of KGM

4.2 Shear flow curve of sol

4.2.1 Different concentrations of the shear flow curve

Fig.2 and Fig.3 showed, sol KGM η with increasing shear rate decreased significantly at 25℃, this shear thinning phenomenon indicated that KGM is typical pseudoplastic fluid. Sol concentrations higher, pseudoplastic characteristics more remarkable. When concentrations of KGM sol below 0.55% , η was affected less by shear rate, showing the approximate Newtonian fluid flow characteristics.

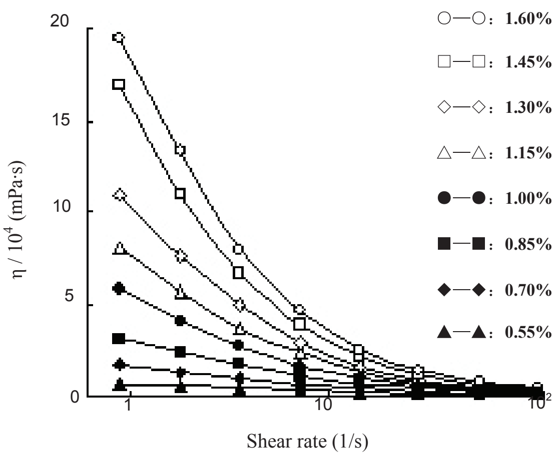

Fig. 2. The effect of shear rate on viscosity of KGM gum.

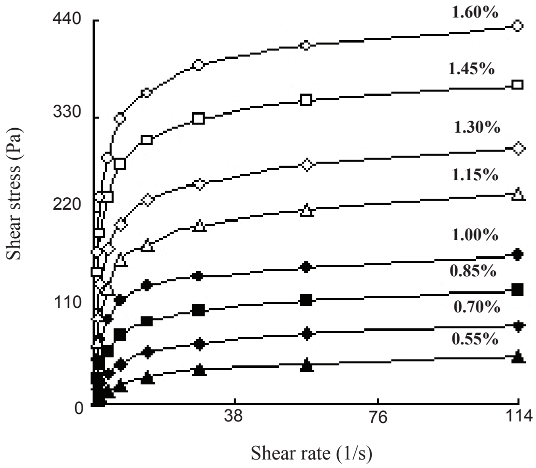

Fig. 3. The rheological curves of KGM gum.

Rheological curve of KGM sol with a power law $\tau = KD^n$ equation, τ is the shear stress, D is the shear rate. Viscosity coefficient K is a measure of the liquid viscosity, K was greater ,the more viscous liquid. Index n is a measure of the pseudoplastic flow, n was smaller, more volatile shear thinning, the greater the degree of pseudoplasticity.

Table 1 lists the values of K and n values of different concentrations KGM sol at 25℃.With KGM sol concentration increased, K value and n valuewere reduced and increased respectively,further reflected pseudoplastic characteristics of KGM sol, but when the KGM concentration of 0.10% sol, K value is very small, n value greater, very close to the Newtonian fluid. In addition to evaluated n value and K value of the quality indicators for the KGM, K greater, n smaller, more excellent quality [9].

Table 1. K and n value of KGM gum of different concentrations.

Concentrations C/(%)	Viscosity coefficient K/(mPa·sn)	Index n
0.10	0.006	0.9883
0.25	0.619	0.5682
0.40	3.262	0.4119
0.55	7.425	0.3640
0.70	19.343	0.3186
0.85	36.019	0.2794
1.00	58.058	0.2370
1.15	88.827	0.2314

1.30	140.540	0.2131
1.45	196.890	0.1837
1.60	239.040	0.1691

4.2.1 Different temperature of the shear flow curve

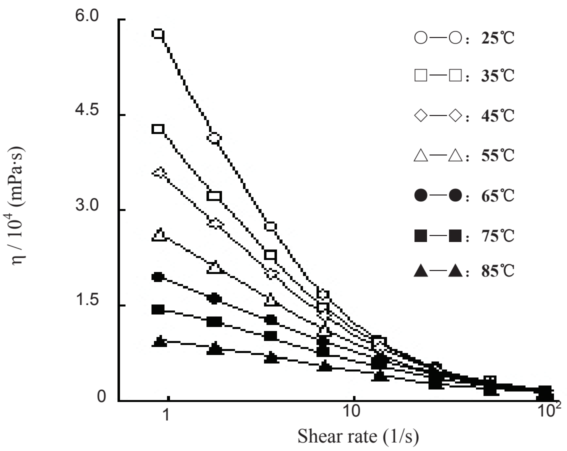

Fig. 4. The effect of shear rate on viscosity of 1.00% KGM gum

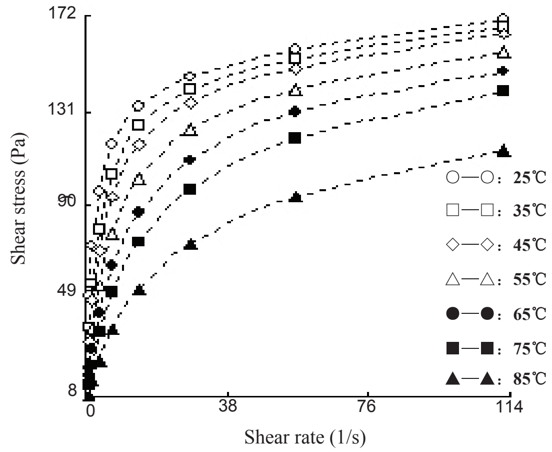

Fig. 5. The rheological curves of 1.00%KGM gum.

Could be seen from Fig.4 and 5, 1.00% KGM sol at different temperatures also showed a clear shear thinning, namely is typical of pseudoplastic fluids. Sol temperature lower, pseudoplastic characteristics more remarkable. However, when the sol temperature is higher than 85℃, η was less affected by the shear rate, close to the Newtonian fluid.

Table 2. K and n value of 1.00%KGM gum at different temperatures.

Temperatures T/(℃)	Viscosity coefficient K/(mPa·sn)	Index n
25	58.058	0.2370
35	48.918	0.2974
45	41.662	0.3306
55	32.739	0.3896
65	22.680	0.4447
75	16.800	0.4964
85	11.060	0.5398

Table 2 lists the value of K and n values of 1.00% KGM sol at different temperatures. KGM sol with increasing temperature, K and n values decrease and increase respectively, which also reflects the characteristics of pseudoplastic on KGM sol, and for KGM sol, the temperature is 85℃, K-value is very small, n values great, showing similar rheological properties of Newtonian fluids.

4.3 Dynamic flow curve of sol

Elastic modulus(G′), loss modulus(G″) and vibration frequency (ω) relationship shown in Fig.6, with frequency increases, G′ and G″rising, and in the entire frequency range (0 ~120rad/s), both are G″ >G′, the dominant role was viscosity on sol system performance. Expiained the molecular chain has a greater rigidity.

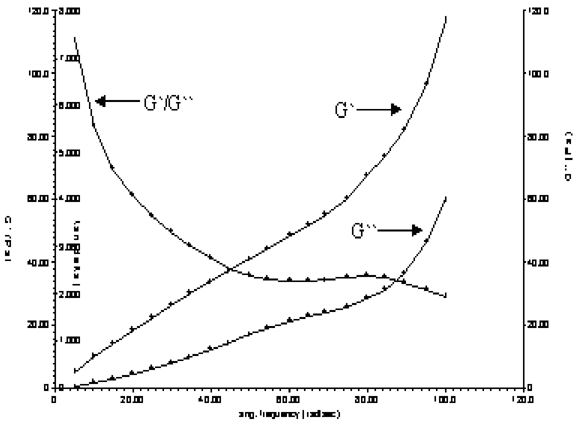

Fig.6. Relation between dynamic modulus and oscillation frequency

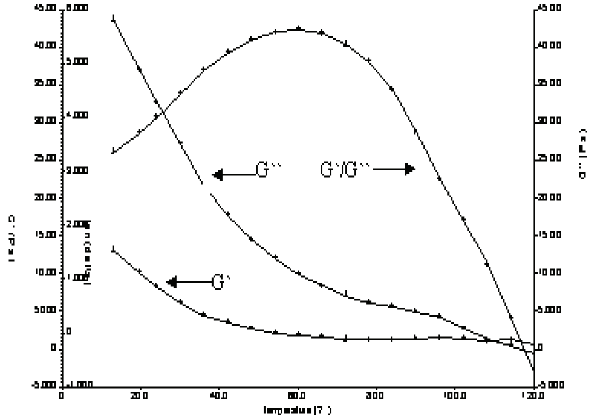

Fig. 7. Relation between dynamic modulus and temperature

Elastic modulus(G′), loss modulus(G″) and temperature (T) relationship shown in Fig.6, in the temperature range, with temperature increases, G′ and G″decrease. At 110℃, G′ and G″appear cross, indicating the viscoelastic system has changed,when 20~110℃, G″ >G′,and viscosity greater than elasticity; when T>110℃, G″ <G′, and viscosity lower than elasticity.

5 Conclusion

5.1 The shear rheological properties of KGM, namely η of KGM and the shear stress and shear rate correlation was significant non-linear variation, in line with a power law ($\tau=KD^n$). Concentration and temperature changes with the value of K and n values of the precise control η for KGM and which brought the physical, chemical and biological properties change, and promoted scientific and rational application of KGM ,and had a practical significance.

5.2 Dynamic flow curve can determined KGM sol system and manily viscous, it showed this may be due to the nature of KGM molecular Centre at random winding.

References

[1]Nishinari K, Konjac glucomannan[J], Developments in Food Science, 2000, 41(25), P309-330.

[2]Dave V, Sheth M, Liquid crystalline, Rheological and thermal properties of konjac glucomannan[J], Polymer, 1998, 39(5), P1139-1148.

[3]Nishinari K, Williams P A, Review of the physico-chemical characteristics and properties of konjac glucomannan[J], Food Hydrocolloids, 1992, 6, P199-222.

[4]Yoo M H, Lee H G, Physical properties of the films prepared with glucomannan from Amorphophallus konjac[J], Korean J. Food. Sci. Tech., 1997, 29, P255-269.

[5]Richard T, Konjac Flour: Properties and Applications[J], Food Technology, 1991, 45(3), P82-92.

[6]Takahiro F, Yohei K, Effects of non-ionic polysaccharides on the gelatinization and retrogradation behavior of wheat starch[J], Food Hydrocolloids, 2005, 19, P1-13.

[7]Shanjun G, Katsuyoshi N, Effect of deacetylation rate on gelation kinetics of konjac glucomannan[J], Colloids and Surfaces B: Biointerfaces, 2004, 38, P241-249.

[8]LI Bin, XIE Bi-jun, Study on molecular chain morphology of konjac Glucomannan[J], Scientia Agricultura Sinica, 2004, 37(2), P280-284 (Ch).

[9]Noriko K, Relationship between the quality of konjac flour and the molecular matter nature of konjac mannan[J], Journal of Agricultural Biological Chemistry, 1979, 43(11), P2391-2392.