



P-ISSN: 2349-8528

E-ISSN: 2321-4902

IJCS 2019; 7(2): 1254-1256

© 2019 IJCS

Received: 19-01-2019

Accepted: 23-02-2019

Aloke Chattopadhyay

Department of Chemistry, S.B.
College, Bagati, Mogra, Hooghly,
West Bengal, India

Studies on grafting in a polymer by using roto viscometer

Aloke Chattopadhyay

Abstract

Guargum is a water soluble natural polymer and has good industrial use. But aqueous solution of guargum has poor biodegradation resistance. To improve biodegradation resistance, polyacrylamide side chains may be grafted on guargum to get guargum-*graft*-acrylamide. Characterization of polymer sample has been done by ESCA study and by thermal analysis. This present work is based in rheological study and it indicates presence of large number of grafted sites in a molecule of the polymer.

Keywords: polymer, rheology, crosslink, apparent viscosity, shearing

1. Introduction

Guargum is water soluble natural polymer and has variety of industrial use^[1]. Its structure is relatively known (fig.1). Major drawback of guargum is its poor biodegradation resistance^[2]. When polyacrylamide side chains are grafted on guargum, resulting graft copolymer becomes more biodegradation resistant and efficient flocculent for metallic ions^[2]. Ceric ion initiation method can be applied for grafting polyacrylamide side chains on guargum and C-2 and C-3 positions (fig.1) may be available for grafting^[2]. Characterization for the graft copolymer (G-g-Am) has been done by ESCA study and thermal analysis and has been reported earlier^[3, 4]. In this present investigation, idea of % graft has been considered basing on rheological studies on aqueous G-g-Am and sodium hydroxide solution mixture and on aqueous G-g-Am, Y(NO₃)₃ solution and sodium hydroxide solution mixture.

2. Materials and Methods

(i) Guargum-*graft*-acrylamide

Guargum-*graft*-acrylamide (G-g-Am) of GM₃ grade has been achieved from Rheological Laboratory of I.I.T., Kharagpur, India.

(ii) Rheological Study

To study rheological behavior, the rotary viscometer RHEOTEST 2 has been used. In RHEOTEST 2, there are two co-axial cylinders (fig.2). The outer cylinder is stationary and has the radius R and forms the measuring vessel. It holds the substance under investigation. The outer cylinder is enclosed by a temperature control vessel which permits connection to a liquid circulation thermostat to provide temperature control of the substance under test. The inner cylinder having the radius r and length l, rotates at a constant angular speed w. The substance subject to investigation is kept in the annular gap (fig.2). The shaft of the inner cylinder is connected to a cylindrical helical spring, the deviation of which is a measure of the torque, M which is effective on the inner cylinder. The deviation of the spring element is scanned by a resistance potentiometer in a bridge circuit. The changes of current in the diagonal branch of the bridge are proportional to M.

Shearing stress, $\tau = \alpha.z$

Where, τ = shearing stress (10⁻¹ Pa.)

α = graduation mark reading of instrument (skt)

z = constant of cylinder (10⁻¹ Pa./skt)

z depends upon dimensions of the cylinder system and on the spring constant of the dynamometer.

Correspondence

Aloke Chattopadhyay

Department of Chemistry, S.B.
College, Bagati, Mogra, Hooghly,
West Bengal, India

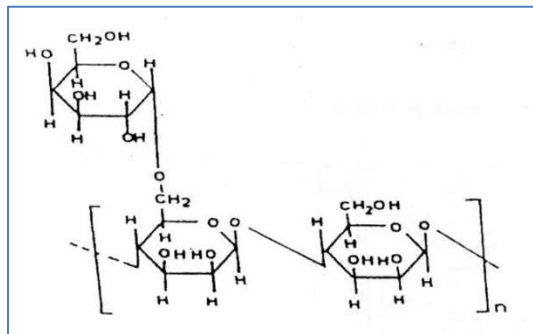


Fig 1: Structure of guar gum

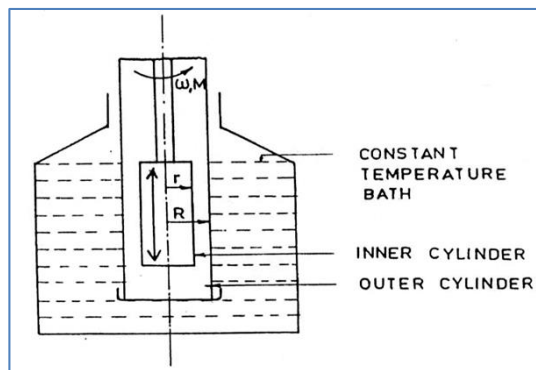


Fig 2: Co-axial cylinder system (Roto viscometer)

$Dr \Rightarrow$ shearing gradient (s^{-1})

Dr is also termed the speed of deformation and gives the speed gradient in the annular gap. It depends on the dimensions of the cylinder system and is proportional to the speed of the rotating cylinder.

$Drk \Rightarrow$ corrected shearing gradient

$$\Rightarrow \frac{Dr \cdot f}{50}$$

$f \Rightarrow$ mains frequency (cycles/sec.)

For rheological study, temperature used approximately $30^{\circ}C$ and experiment has been done by filling 5 ml. of solution for aqueous G-g-Am, 3 ml. of 0.2(M) $Y(NO_3)_3$ solution and 5 ml. of 60% NaOH solution in the annular space of the co-axial cylinder system and allowing the mixture to stand for 15

minutes before start of shearing. For G-g-Am- Na^+ , filling of 5 ml. of solution for aqueous G-g-Am and 6 ml. of 60% NaOH solution in the annular space of the co-axial cylinder system is done. It has been found that α depends upon time. So α has been determined after approximately 2 minutes of application of shearing^[5].

$Y(NO_3)_3$ solution has been prepared by dissolving Y_2O_3 in nitric acid.

3. Results and Discussion

Rheology is the science of deformation and flow under the application of shear stress. In this present investigation, ideas of apparent viscosities for aqueous G-g-Am and aqueous NaOH mixture (G-g-Am- Na^+) and for aqueous G-g-Am, $Y(NO_3)_3$ solution and aqueous NaOH mixture (G-g-Am- Y^{3+}) are done.

Table 1: Rheological values for Gg-g-Am- Y^{3+} , channel -1, $z = 3.21$

Position	Dr	f	Drk	α	τ
1b	1.5	47	1.41	62	199.02
2b	2.7	48	2.592	33	105.93
1a	3	48.5	2.91	30.5	97.905
3b	4.5	49	4.41	39.5	126.795
2a	5.4	49.5	5.292	40	128.4
4b	8.1	49.5	8.019	54	173.34
3a	9	49.5	8.91	65	208.65
5b	13.5	49.5	13.365	95	304.95
6b	24.3	49	23.814	64	205.44
5a	27	48.5	26.19	60	192.6
7b	40.5	48.5	39.285	60	192.6
6a	48.6	48	46.656	40	128.4
8b	72.9	48.5	70.713	42	134.82
9b	121.5	47.5	115.425	35	112.35
8a	145.8	48	139.968	38	121.98
10b	218.7	48.5	212.139	40	128.4
9a	243	48	233.28	40	128.4
11b	364.5	48.5	353.565	36	115.56
10a	437.4	49	428.652	35	112.35
12b	656	49	642.88	38.5	123.585
11a	729	49.5	721.71	42	134.82
12a	1312	49	1285.76	47	150.87

Table 2: Rheological values for G-g-Am-Na⁺, channel -1, z = 3.21

Position	Dr	f	Drk	α	τ
1b	1.5	47	1.41	45	144.45
2b	2.7	47.5	2.565	12	38.52
1a	3	48.5	2.91	9	28.89
3b	4.5	48.5	4.365	11	35.31
2a	5.4	48.5	5.238	11.5	36.915
4b	8.1	48	7.776	10	32.1
3a	9	48	8.64	9.5	30.495
5b	13.5	47.5	12.825	10	32.1
4a	16.2	48	15.552	10	32.1
6b	24.3	48.5	23.571	11.5	36.915
5a	27	49.5	26.462	10.5	33.705
7b	40.5	49.5	40.095	11.2	35.925
8b	72.9	49.5	72.171	20	64.2
7a	81	49	79.38	12	38.52
9b	121.5	49.5	120.285	16	51.36
8a	145.8	49.5	144.342	17.5	56.175
10b	218.7	49.5	216.513	21	67.41
9a	243	49.5	240.57	22.5	72.225
11b	364.5	49.5	360.855	27.5	88.275
10a	437.4	49.5	433.026	30.5	97.905
12b	656	49.5	649.44	40	128.4
11a	729	49.5	721.71	43.2	138.672
12a	1312	49	1285.76	66.9	214.749

Following equation may be used:

$$\eta_{app} \Rightarrow \frac{\tau \times 100}{Drk}$$

Where, $\eta_{app} \Rightarrow$ apparent viscosity

Shearing gradient and shear stress for G-g-Am-Y³⁺ and for G-g-Am-Na⁺ are shown in Table-1 and Table-2 respectively. Tables indicate, τ value decreases more for higher Drk values for G-g-Am-Y³⁺ than that for G-g-Am-Na⁺. This indicates presence of large number of grafted sites in a molecule of polymer for which they are creating more resistance to flow at higher Drk values in case for G-g-Am-Na⁺ [5]. In case for G-g-Am-Y³⁺, cross links may be present [6] but for G-g-Am-Na⁺, grafted chains are expected to be much more non-entangled.

4. Conclusion

ESCA study can give idea of % of C, N and O present in a sample of the polymer [3]. DSC studies can give idea for grafting of polyacrylamide chains on guar gum by showing shift of position of endotherm for anhydrification and cyclic imide formation due to grafting [4]. But idea of % graft, is very difficult to achieve from these methods. This hard task may become easy by rheological study basing on the fact that, higher the resistance to flow, higher is the apparent viscosity. This work is a tacit method to understand higher resistance to flow of the mixture at higher shearing cases for G-g-Am-Na⁺ when compared with similar cases for G-g-Am-Y³⁺. In case for yttrium ion bound guar gum-graft-acrylamide (G-g-Am-Y³⁺), mass is much more tight probably due to cross linking [7] and at very high Drk, there will be difference in behavior for

G-g-Am-Y³⁺ and for G-g-Am-Na⁺ to give the idea of % graft in case for G-g-Am.

5. Acknowledgment

Author acknowledges thanks to Dr. R.P. Singh and the authority of I.I.T., Kharagpur, India for help.

6. References

1. Pezron E, Ricard A, Lafuma F, Audebrit R. *Macromolecules*. 1988; 21:1121-1125.
2. Deshmukh SR, Chaturvedi PN, Singh RP. *J Appl. Polym. Sci.* 1985; 30:4013.
3. Chattopadhyay A. *Int. J Chem. Studies*. 2015; 2(6):05-08.
4. Chattopadhyay A. *Int. J. Chem. Studies*. 2019; 7(1):1384 – 1385.
5. Chattopadhyay A. *J Technol*. 2012; XXXXII:49-66.
6. Chattopadhyay A, Bhattacharya D, Singh RP. *Materials Letters*. 1995; 25:277-283.
7. Chattopadhyay A. *Int. J Chem. Studies*. 2018; 6(2):1466-1469.