



AA, ACR and AN based Copolymer Thickener; its Utilization in Printing of Natural Polyamides with Reactive Dye

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Abstract

Present work deals with the integration and characterization of synthetic thickener, formulated by free radical polymerization of Acrylic acid, Acrylonitrile and Acrylamide. Characterization of thickener confirmed with Fourier Transform Infrared spectral data, rheology and viscosity. The formulated thickener was utilized for the preparation of reactive printing paste in with different concentrations; printed on natural polyamides, the same procedure undertaken for study with guar gum and sodium alginate. The characteristics of prints such as K/S value, strength, fastness to washing, dry/wet rubbing, and light assessed. The highest K/S value and excellent fastness properties were found in samples which were printed using formulated polymer.

Keywords: Synthetic thickener; Acrylic acid; Reactive printing; Acrylamide; Wool printing; Silk printing

Introduction

A choice from a variety of colors and their patterns makes the uniqueness of the person in the colorful world. Introduction of color in our life occupies interest of many sciences, arts, businesses, and industries. The term 'printing' was coined in the 18th century and is derived from a Latin word meaning 'pressing'. Printing is a very common technique which is the process of addition of color in a restricted area to form a colorful design. When a textile material is printed with different colors in various colored patterns called as textile printing and it is one of the cheapest methods of ornamentation of fabrics. Textile printing has two sides, namely the art of designing and scientific technology applied for printing. These both objectives are achieved with the chemical characteristics of a thickener used for textile printing and its physical applicability on textile materials. Now a day, therefore, chemistry for the printing of cotton with reactive dye

is crucial in textile industries. The sharp and best printing is achieved by selecting suitable thickeners for preparing printing paste. Thickeners are those components of printing paste that impart a printable, paste consistency to other aqueous liquor and mainly consist of thickening agents. Thickeners are supplied in concentrated form for storage purpose. Asian textile industries approving 80 % area with reactive printing incorporate textile wet processing. Generally, natural thickeners are utilized for the printing of cotton with reactive dye. Natural thickeners like guar gum and sodium alginates are massively used for printing reactive dye on textile. Even guar gum has a wide range of applications, it shows some discrepancies, like immoderate rates of hydrolysis, pH amenable solubility and high susceptibility to microbial attack. Chemical alteration suggests an amendment for displacing these discrepancies with amending swelling and solubility. Sodium alginate, mixed with guar gum and also with emulsion used for printing reactive dye popularly in Asian textile industries. Alginate proved exquisite brightness and the color yield on textile for reactive dye. Both guar gum and sodium alginate are utilized in the textile printing area. Also, acrylic resins are aggrandized for printing, though they are used in acidic medium, are not facilitate for reactive dye printing. These thickeners have particle range between 8 – 80 μ . All the synthetic polymers which possess the attributes of thickeners are applied in pigment printing only. Synthetic thickeners, predominate in the printing of pigments due to their low solids content. They additionally offer an advantage over natural thickeners in quick and easy paste preparation and viscosity adjustment, and consistency of quality and supply. Today the necessity to print reactive dyes economically with high quality has led to the commercial development of synthetic thickeners in this application. Present research work aims to examine the printing properties of a reactive dye paste based on natural thickeners and two formulated synthetic thickeners, and to determine if such synthetic thickeners can overcome disadvantages, while not losing the advantages for which each is known. Many variables might be examined, but generally, a printer is looking for a paste that is simple to prepare, stable, prints level and sharp, minimizes the use of dye and auxiliaries, and easy to remove. The purpose of the present studies is to formulate polymer which possesses the desired properties of thickener, which can also commute Guar gum, Sodium Alginate from reactive printing on cotton fabric. Also, that thickener can serve excellent sharpness, brightness and color yield on textile. Acrylic acid and its ester-based acrylic thickeners are generally used for printing, where acid comonomer is responsible for viscosity. Presence or absence of crosslinking agent also alters the alkali swell ability of thickeners, which depends on glass transition temperature (T_g) of thickeners. Innovations start with urethane-based on three low molecular weight hydrophobic groups. This polymer is synthesised in the non-aqueous medium using polyether polyol, water-soluble an organic polyisocyanate, water-insoluble. This linear polymer product can replace natural thickeners in particular manners, like household, medical, personal care and agriculture composition. Many synthetic thickeners composed of carboxylic acid monomers, such as acrylic acid, and polyfunctional crosslinking monomers, based on non-ionic surfactant acrylates. Acrylic acid and its ester are polymerising using azobisisobutyronitrile as the initiator. The resultant polymer is insoluble in the organic solvent.

Experimental

Materials

Acrylic Acid (AA), Acrylamide (ACR) and Acrylonitrile (AN), which were provided by A.B. Enterprise (India), disinfected by treating with 10% sodium hydroxide solution followed by washing with deionized water. Toluene (Solvochem) and ethyl acetate (Arihant chemical) were used as a solvent. Triallylamine (TAA) (Shandong

Luyue Chemical), Triallylphosphite (TAP) (Shandong Luyue Chemical), Benzoyl Peroxide (BP) (A.B. Enterprise), Tert-Butyl Hydro Peroxide (TBHP) (Triveni Chemicals). The fabrics were procured from the market and their specifications are given in Table 1. The reactive dye used for the studies is list.

Guar gum and sodium alginate (natural thickeners) were used as reference standards in preparation of printing paste for comparative studies.

Material	Weave	Reeds/inch	Picks/inch	GSM (g/m2)
Wool	Plain	75	40	132
Silk	Plain	90	85	125

Table1: Textile material used for printing.

Polymerization Procedure

Components for copolymerization process for the synthesis of novel polymeric thickeners [A-E] based on AA, ACR and an monomers were presented in Table 2.

Monomers	Monomer-a=Acrylic Acid,
	Monomer-b=Acrylamide and
	Monomer-c=Acrylonitrile
Solvent system	Solvent-I=Toluene and
	Solvent-II=Ethyl Acetate
	(Solvent Mixture of I:II is 60:40)
Cross-linker	Triallylamine, Triallylphosphite
	in equal proportions
Initiator	Benzoyl Peroxide
Inhibitor	Tert-Butyl Hydro Peroxide (TBHP)

Table 2: Components for polymer preparation.

Five necked round bottom flask of 1000 ml capacity set with a double-helical parallel impeller agitator, thermometer, additive funnel, and nitrogen gas inlet tube and water condenser as shown in Figure 1. Add two small pieces of porcelain chips and transfer 200 ml of 60:40 v/v solvent mixture (120 ml toluene and 80 ml ethyl acetate) into the flask. Now pass the nitrogen gas to sparge the flask contents to expel the air, meanwhile slowly heat the solvent mixture to 40 °C temperature. The additive funnel is filled with 50 ml of monomer feed (containing the solvent mixture, monomers, and cross-linker) and the feed is added drop wise at the rate of 3.0 ml/min under a continuous

stream of nitrogen gas. Gradually increase the temperature to 80 °C, after adding 0.01% by weight benzoyl peroxide to initiate the polymerization. After completion of addition of 50 ml monomer feed, the remaining 200 ml of the monomer feed is transferred into the additive funnel and it is added continuously throughout 1.5 h. Temperature is maintained at 80 – 90 °C during the whole polymerization process. At the end of the reaction, 0.01% by weight TBHP is added to inhibit the polymerization reaction. Reaction mechanism of free radical polymerization of the monomers is suggested in Figure 2. Various compositions for series of experimental runs are given in Table 3.

Experiment	Polymer	Monomer (g)			Cross Linker (g)	Solvent (ml)		Temperature (°C)
		a	b	c		I	II	
I	A	80	20	1	0.01	240	160	80 – 90
II	B	70	30	1	0.01	240	160	80 – 90
III	C	60	40	1	0.01	240	160	80 – 90

IV	D	50	50	1	0.01	240	160	80 – 90
V	E	40	60	1	0.01	240	160	80 – 90

Table 3: Components and amounts are set forth for polymers A-E.

After completion of polymerization, rotary evaporator under vacuum is utilized for isolation of the polymer product by removing solvents. The yield of the polymer product is almost quantitative.

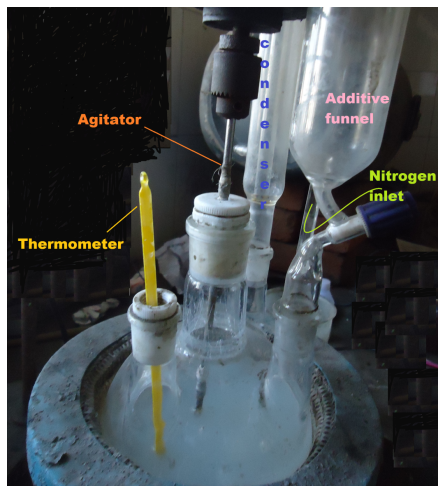


Figure 1: Assembly setup for polymerisation process.

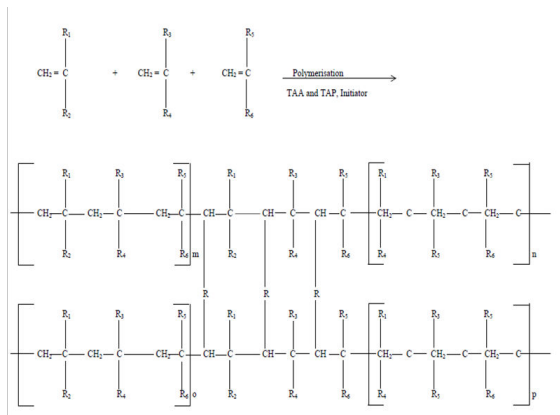


Figure 2: Reaction mechanism.

Viscosity Measurements

Preparation of the polymer paste for viscosity measurements

Dissolve 25 g of sample polymer, previously dried in a vacuum at 80 C for an hour, to 500 mL of water in a 1000-mL beaker, while stirring continuously at 1000 ± 10 rpm, with the stirrer shaft set at an angle of 60 C and to one side of the beaker, with the propeller positioned near the bottom of the beaker. Allow 45 to 90 seconds for the addition of the test preparation at a uniform rate. Remove the stirrer, and place the beaker containing the polymer paste at room temperature for 30 min. Insert the stirrer to a depth necessary to ensure that air is not drawn into the paste. Neutralize the paste by drop wise

addition of liquor ammonia (5 ml) with vigorous stirring. Determine the final pH of the resulting mixture, when neutralization is just completed. Note that if the pH is below 7.0; raise pH with additional liquor ammonia. If pH is above 7.1, discard the mixture, and prepare it using the smaller proportion of liquor ammonia than previously used one. Perform the viscosity determination without delay to avoid slight viscosity changes. Equip a suitable rotational viscometer and follow the manual directions to measure the paste viscosity.

General method for viscosity measurements

The DV-E rotational Brookfield viscometer Figure 3 is used to measure viscosity by measuring the force required to rotate a spindle in a sample fluid.



Figure 3: DV-e rotational brook field viscometer.

Calibrate the viscometer before its use. Fill the sample into the sample holder. Now adjust the gap between the cone and the plate by moving the plate built into the sample cup up towards the cone until two small pins (one in the cone, the second mounted on the plate) contact slightly, and then by separating (lowering) the plate 0.0005 inches (0.013 mm). Immerse the appropriate spindle into the sample to the groove on the spindle shaft. Do not allow air bubbles to be formed. Attach the spindle to the viscometer. The spindle should not touch the bottom or sides of the container and should be centered. Connect a circulating temperature bath controlling temperature (within ±0.1 °C) to the ports on the sample cup. Reconfirm that the viscometer is level. Set the speed as designated in the product specification, start the viscometer and read the viscosity from the display. Readings were recorded in Table 4. When measurements were done, turn motor and power off. Clean spindle and place in spindle holder.

Polymer	Amount of Polymer (g)	Liquor Ammonia (g)	Water (g)	Viscosity (cP)
A	25	5	470	20000
B	25	5	470	10000
C	25	5	470	5000
D	25	5	470	3000
E	25	5	470	2000

Table 4: Viscosity of 5% w/w pastes prepared using polymers A-E.

Natural thickeners (Sodium alginate and Guar gum) used for reactive dye printing have a viscosity of 15000 – 20000 cP, measured by rotational Brookfield Viscometer. (Spindle number 6, 20 rpm at 20 °C temperature). The inspection of viscosity results reveals that the polymer-A is best suitable for replacing natural thickeners in making of paste used for textile printing.

Thermo Gravimetric Analysis (TGA)

Set the nitrogen and oxygen gas flow rates to provide the heating rate of 20 K/min. Place 1.0 g of sample polymer material in the specimen holder and raise the furnace temperature. Set the initial weight (1.0 g) reading to 100%, and then initiate the heating program. TGA measures the mass change in the samples and it is used to detect evaporation, decomposition, oxidation and other effects of temperature change that cause mass changes. Data are recorded as a plot of per cent weight loss versus temperature.

TGA investigations of sodium alginate, guar gum, their mixtures and the polymeric thickeners were carried out with 1.0 g of initial sample material at the heating rate of 20 K/min using Parkin Elmer TGA model. The recorded TGA curves are presented in Figures 4.1-4.4

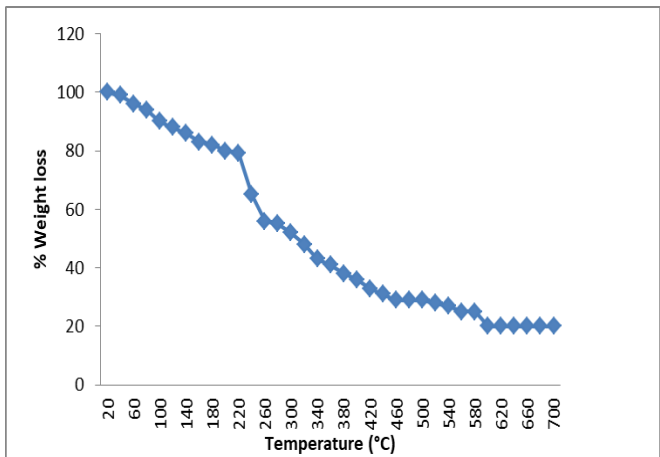


Figure 4.1: TGA curves for sodium alginate.

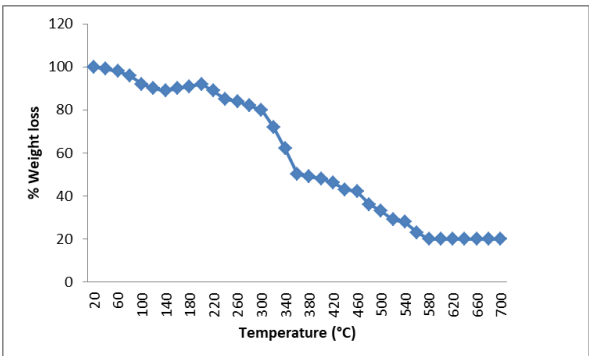


Figure 4.2: TGA curves for Guar gum.

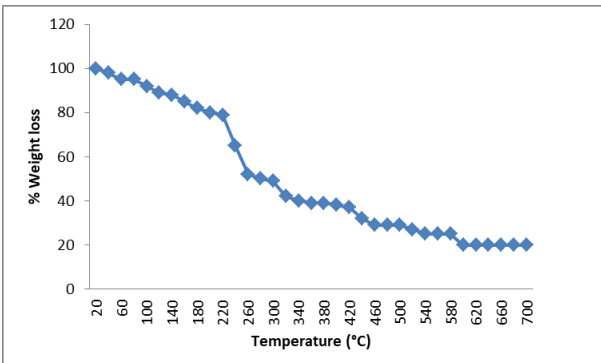


Figure 4.3: TGA curves for mixture of guar gum and sodium alginate.

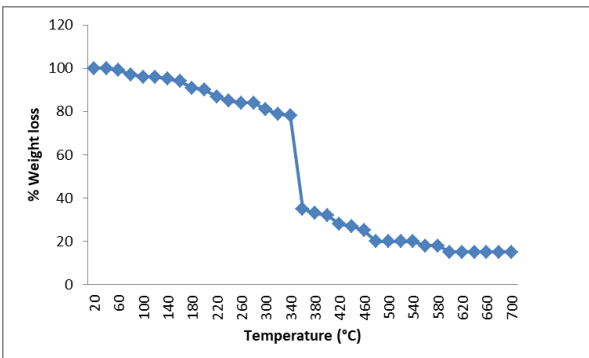


Figure 4.4: TGA curves for synthetic thickener (Polymer-A).

FTIR Spectrometric Studies of Polymer

The characterization of the prepared polymeric thickener is very difficult due to its insolubility. NMR study of this polymer was closely impossible, but FTIR spectra were recorded (Figure 5) by preparing a polymer sample's film using the latex surface of the glass, then removing from the glass.

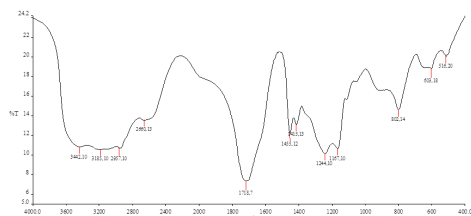


Figure 5: IR spectral transmittance of Polymer-A.

Rheological Characterization

Rheological characterization was performed for the formulated thickener against the references (guar gum and sodium alginate).

Thickener	Critical Shear rates (S-1)	Crossover ω (rad/s)	Horizontal shift factor a	Vertical shift factor b
SA	0.936	180.11	1	1
GG	0.826	172.12	0.981	1.121
SA + GG	0.892	175.34	0.996	1.072
Polymer-A	0.94	181.25	0.998	1.021

Table 5: Critical shear rate of the thickeners with cross model at 25 °C.

The flow time of the thickeners was measured. The effects of pH, storage time and presence of electrolyte have also been studied by using Visco cup method using a stock solution of 1% w/w polymer thickener in water. The results were presented in Tables7-9.

Thickener ↓ pH →	Flow time / s					
	2	4	6	8	10	12
SA	28	32	56	112	125	107
GG	26	29	54	100	108	102
SA + GG	29	31	58	109	117	103
Polymer-A	52	79	99	106	119	108

Table 6: Flow time of thickeners at different pH.

Thickener ↓ Conc. /gpl →	Flow time / s					
	5	10	15	20	25	30
SA	32	46	68	99	102	96
GG	27	31	65	101	116	98
SA + GA	30	42	71	95	107	92
Polymer-A	56	89	105	112	109	94

Table 7: Flow time of thickeners at different conc. of electrolyte.

Thickener aqueous systems were prepared by adding the dry powder into distilled water with continuous vigorous stirring. The concentration of the thickener's stock aqueous solution was chosen to fit the rheological constrain of equal viscosity (at 25 °C) of the corresponding printing pastes: $\eta = (7.3 + 0.8)$ Pas at $\gamma = 10$ s⁻¹. Sodium alginate thickener was studied at 4% w/w stock solution concentration. However, guar gum and the formulated thickener were analyzed at 3% w/w concentration.

Rheological measurements, the rotational measurement was carried out at 25 °C and performed with a rotational controlled stress rheometer Haake RS150 (Searle System) using cone and plate (C60/1) measuring device. The resultant displacement (strain) was measured. The apparatus was computer-controlled and the temperature was maintained with a thermostat (Table 5-8).

Thickener↓ Time interval / h →	Flow time / s					
	2	8	24	48	192	288
SA	112	105	99	84	46	35
GG	108	103	97	72	41	28
SA + GA	105	102	95	91	62	42
Polymer-A	121	114	109	98	63	45

Table 8: Flow time of thickeners at different time interval.

Recipe of Printing Paste

A successful print involves definite color, the sharpness of mark, levelness, precise hand and efficient use of dyes. All of these factors depend on the chemical characteristics of thickener used and its physical applicability on textile materials. The thickener must be compatible with other ingredients present in printing paste. The natural polyamide textiles like silk, and wool, were printed using the paste containing formulated synthetic thickeners. The recipe of the printing paste. The printing of reactive dye on silk and wool was carried out by laboratory flatbed screen printing machine using a direct style method. Four different thickeners were used for every comparative experimental study, namely Guar Gum (GG), Sodium Alginate (SA), Mixture of GG and SA; and the synthesized polymer thickener.

The sample printed with sodium alginate paste was dried and then cured at temperature 150 °C for 5 min. The similar procedure is also followed for guar gum except curing was done at 135 °C for 4 min. The same manner is followed by a mixture of natural gums. However,

in the case of the polymer thickener, it was cured at 150 °C for 4 min. All the samples were then washed, soaped at 60 °C for 10 min, rewashed and finally dried. These printed samples were used for the comparative performance studies of printing.

Performance Studies

Color value

The printed samples were assessed for the depth of color by reflectance methods using a 10-degree observer. The absorption of printed samples was measured on Premier Spectrascan SS 5100H. The relative color strengths (K/S values) were computed using Kubelka-Munk expression and shown in Table 9a and b for different reactive dyes.

$$K/S = (1 - R)^2 / 2R$$

Where, R = decimal fraction of reflectance for the printed material at complete opacity λ_{max} of the dye), K=absorption coefficient, S=scattering coefficient.

% Shade	1 %			3 %	5 %				
Thickeners used for paste	GG	SA	A	GG	SA	A	GG	SA	A
K/S Value	6.5	23.4	27.2	25.2	45.2	46.3	43.8	55.2	56.2
Strength (%)	26.4	100	108	58.2	100	100	80.6	100	102.8

Table 9a: K/S value and strength of wool printed samples for RR141.

% Shade	1 %			3 %	5 %				
Thickeners used for paste	GG	SA	A	GG	SA	A	GG	SA	A
K/S Value	6.9	24.7	29.4	26.8	44.7	47.8	38.2	52.1	56.3
Strength (%)	26.6	100	120.8	58.1	100	105.7	74.9	100	108.2

Table 9b: K/S value and strength of silk printed samples for RR141.

Fastness testing

The washing fastness, light fastness, rubbing fastness, hot pressing fastness, hydrogen peroxide fastness, sodium hypochlorite fastness and perspiration fastness tests were carried out according to AATCC

test methods: 61 – 2006 using Launder – o – meter, 16–2004 using Fed – O – Meter, 8 – 2005 using Crock-meter, 133 – 2013 using a hot iron, 101 – 2013, 188 – 2010 and 15 – 2002 using perspirometer respectively. The results were presented in Table 10a and b for different reactive dye.

% Shade		1 %	3 %	5 %						
Thickeners used for	paste	GG	SA	A	GG	SA	A	GG	SA	A
Washing		3	3/5	4/5	4	4	5	3/5	3/4	4/5
Rubbing	Dry	4	4	5	3/4	4/5	4/5	4	4	5
	Wet	3/4	3	4	3/4	4/5	4	3/5	4/5	4/5
Light		3	3/4	4	4	4	5	3/4	4/5	5
Perspiration		4	3	4/5	4	4/5	4/5	4	4/5	5
Bleaching	H2O2	3/4	4	5	4	3/4	4/5	4	4	5
	NaOCl	2	3/4	3/4	3/4	3	3	2/3	3/4	4
Hot Ironing		3	3	4	3	4	4/5	3	4/5	4/5

Table 10a: Various fastnesses of RR141 dye with polymer printed on wool.

% Shade		1 %	3 %	5 %						
Thickeners used for	paste	GG	SA	A	GG	SA	A	GG	SA	A
Washing		3	3/5	4/5	4	4/5	4/5	4	4/5	4/5
Rubbing	Dry	4/5	4/5	3/5	3/5	4/5	4	4	5	5
	Wet	3/5	4/5	3/5	4	4/5	4	4	5	4/5
Light		3/5	3/4	4	4	4	4/5	3	3/5	4/5
Perspiration		4	3	4/5	4	4/5	4/5	4	4/5	5
Bleaching	H2O2	3/5	4	4	3/4	4/5	3/5	3	4/5	5
	NaOCl	3/4	3/4	3/4	3	3	2/3	3/4	4	4
Hot Ironing		3	3/5	4	3	4	4/5	3	4/5	4/5

Table 10b: Various fastnesses of RR141 dye with polymer printed on silk.

Results and Discussion

FTIR analysis

The characterization of the copolymer thickener is very difficult due to its insolubility. NMR study of the polymer is closely impossible, but FTIR spectrum was recorded by preparing sample's

film of the latex surface of the glass and then removing from the glass. The FT-IR spectrum of the polymer product (synthetic thickener). The characteristic IR bands were identified and assigned for the structure determination of the polymer. The structure of the polymer was confirmed from the summation of all IR band assignments including the disappearance of C=C stretching vibrational peak at 1638 cm⁻¹ (due to its polymerization reaction) in the IR spectrum.

The characteristic IR bands of polymer – A	
IR band/ cm ⁻¹	Assignment(s)
3442–3300 (s, b)	Asymmetric stretching vibration of NH ₂ group which is overlapped with alcoholic –OH group
3185 (s, b)	symmetric stretching vibration of NH ₂ group
2957 (m, b)	C-H bond asymmetric stretching vibrations of CH ₃ group
1738 (s, b)	Characteristic stretching vibrational shoulder band of C = O bond in all poly(AN-co-AA) AA was successfully copolymerized with AN

1386–1449 (m)	C-H bond rocking vibration of CH ₃ group
1455-1415 (w)	bending vibration of >CH- adjacent to –CO–
1244(m)	Stretching vibrational of >CH- adjacent to –CO–
1167 (m)	in-plane-deformation of C–O–C (the polymer is present in normal plane structure which deforms)
802, 603 and 516 (w)	vibrations of –CH ₃ group coupled with skeletal structure

Thermo Gravimetric Analysis (TGA)

The inspection of TGA curve for sodium alginate reveals that by heating the polymer a slight initial weight loss was observed due to loss of adsorbed water. The steep fall in weight was recorded over the temperature range of 240-300 °C. This second stage of significant weight loss belongs to the fast degradation of sodium alginate.

Represents a TGA curve of guar gum. Initially, a minute weight loss due to desorption of water was recorded. Nonetheless, the sharp change in the range of 300 to 380 °C was observed due to the rapid degradation of guar gum.

When sodium alginate and guar gum mixed as per industrial standard, The TGA curve of the mixture has exhibited sharp weight loss in the range of 220–280 °C. The results predict the influence of sodium alginate on the thermal stability of guar gum.

Polymer-A confirm outstanding thermal stability of the polymers up to 340°C temperature. An initial weight loss was observed due to moisture traces present in the polymer. The slower weight losses were seen in the range of 340–380 °C for polymer-A. Although the products are synthetic polymers, they undergo slow cleavage of polymer backbone over a higher temperature range.

Rheological Studies

Table-6 has indicated that sodium alginate, guar gum and their mixture have identical critical shear rate and also good horizontal shift as well as a vertical shift. The results indicated that the polymer thickener is outstanding above sodium alginate, guar gum and their mixture. Chemically, the polymer thickener with a higher shear rate suggests the swelling of polymer molecules in water with high speed stirring at room temperature. Due to this swelling, the molecules of thickeners absorb more water contents than their high solid contents. It has also reduced the surface tension of the bath and increased density of the polymer.

The flow time of thickener had been studied to justify the shear rate and it has to pass through the critical mesh of the screen made by polyester or nylon. As the flow time is higher than can be applied very perfectly on the fabric using various printing machinery. The inspection of table-7 has revealed that all the thickeners showed optimum flow time at nearly 10 pH, *i.e.*, all thickeners are stable in alkaline medium compare to acidic. At 2, 4 and 6 pH values, all pastes have exhibited lower flow times. This means the viscosity is much lower that can easily pass through the screen for printing, will spread the printed area on the fabric at this particular pH. As pH increased from 2 to 6, the table also has indicated a constant rise in flow time. Nonetheless, after 8 pH, sodium alginate, guar gum, their mixture and the polymer have shown the drastic rise in flow time. Finally, at 10 pH, the polymers exhibit exactly suitable flow time which is desired

by textile printing industries for reactive dye printing on various fabrics. After 10 pH, the flow times were reduced.

Reactive dye printed fabric is soaped using non-ionic detergent, soaping bath contains electrolyte such as sodium chloride, sodium sulphate for improving the levelness of design and removing of thickener, so the washout action of thickeners in presence of electrolyte is also an important criterion. Table-8 indicates the flow time of thickeners at different concentrations of sodium sulphate which is widely used in textile printing industries. The flow time of thickeners is much higher when the concentration of the electrolyte is 25 g/l, and at minimum concentration; the flow time is also lower. The optimum concentration for washing in textile industries was 10 g/l and for printing paste, 20 g/l. While comparing with industrial criteria, sodium alginate, guar gum and their mixture showed good achievements in flow time, as well prepared polymer indicated better improvement in flow time at both standard concentrations of electrolyte.

Generally, textile industry prepares stock paste of thickeners in bulk and utilizes paste from this stock to fulfill the various demands from time to time. For this reason, thickener should possess stable viscosity during its storage. So it is necessary to test the flow time of thickeners at a different time interval. Natural thickeners are stable till 8 h, as per required viscosity for the printing of reactive dye as presented in Table-9. However, after 8 h the flow time decreases to 48 h and then its viscosity increases drastically to be a thick mass. This concludes that viscosity of references is maintained up to 8 h only.

The results of Table-9 have indicated that the paste of synthesized polymer was stable throughout 24h and so the paste can be stored for 24 h. After this particular time, flow time decreases, by decreasing in viscosity. Once again this analysis also proves synthetic thickeners are suitable to compare to ideally used natural thickeners in reactive printing industries.

Performance Studies

Color value

K/S value suggests a ratio of absorption and scattering view of the printed sample, concerning reflectance, as well the strength of shade indicates the shade concentration compared to control one. Table 12-A shows that the greatest K/S value and color strength achieved in case of RR141 reactive dye on wool using the formulated polymer thickener. When the fabric was changed by using silk for the printing of reactive dye, polymer gave a good result of K/S value as well the strength of shade than the natural polymers used as thickeners (Table 12B). The results of Table 12A and 12B have revealed that the highest K/S value and color strength achieved in case of RR141

reactive dye on silk and wool using the synthetic polymer as thickener compared to the reference.

Washing, light and rubbing fastnesses

Washing fastness of reactive RR141 on silk and wool has better results for the formulated thickener than reference standards thickeners in all combination of shade, but in case of 1%, sodium alginate has good results (Table-13A and B). Both tables suggest that excellent washing fastness had been achieved for reactive dye RR141 using the polymer thickener and fairer to that using sodium alginate, while guar gum gave average washing fastness. Both dry and wet rubbing fastnesses of RR141 on silk and wool have excellent results when printed with the polymer thickener. Sodium alginate and guar gum have performed average and deprived fastness, respectively (Table 13A and B). For both the fabric, the polymer thickener has shown outstanding rubbing fastness, while guar gum and sodium alginate have shown average fastness compare to it.

Light-fastness is the measurement of the dye fading by continuous exposure of light on the printed fabric under specific conditions, which suggests the dye strength to some extent towards the light. In case of printing of selected reactive dye viz., Reactive RR141, on silk and wool fabric, all three dyes indicated excellent light-fastness when printed using the polymer thickener as well sodium alginate, the light-fastness was below average for guar gum. This concludes that the synthetic polymer thickener has better result compare to the standard reference (Table 13-A and B).

Wool printed with RR141 shows (Table 13-A) pitiable to average perspiration fastness utilizing polymer-A and natural thickeners. Reactive dye RR141 printed on silk provided superior fastness results in 1% shade for guar gum. But in 3% and 5% shade, fastness is unfortunate (Table 13-B). Although for 3% and 5% shade polymers-A have presented better fastness than sodium alginate.

Conclusions

The research work has concluded that novel polymer thickeners based on co-monomers of AA, ACR and an have been successfully synthesized *via* free radical solution copolymerization. From the FT-IR spectra, it was confirmed that the synthesized copolymers-A was indeed poly (AA-co-ACR-co-AN).

The thermal analysis of polymer-A has provided outstanding thermal stability of polymer-A up to 340 °C temperature.

Rheological studies have concluded that the polymers-A has better rheological behavior than that of sodium alginate and superior to guar gum and their mixture. Chemically, the thickeners with high shear rate suggest that the swelling reaction in the water at room temperature with high-speed stirring. Due to this swelling, the molecules of thickeners absorb more water in contents of high solid contents; it also reduces the surface tension of bath and increases the density of the product.

It was also concluded that polymers-A thickeners exhibited optimum rheological behavior at 10 pH, 10 g/l electrolyte concentration for washing and 20 g/l for printing paste. It was also concluded that pastes of polymer-A were stable for 24 h and so the paste can be stored for a day.

Printed natural polyamide using natural thickeners suggested good K/S value, but these values were shown excellent when novel prepared thickeners utilized for the same purpose. Polymer-A suggested better result in case of 3% and 5% shade printed on wool, while in 1% shade they showed poor performance than natural thickeners, especially sodium alginate. All the fastness has also shown excellent result while prepared thickeners are used for printing of reactive dye by the direct style of printing. K/S value of wool fabric printed with reactive dye by applying Polymer-A has a better result than natural thickeners utilised paste. Also, there was a remarkable increment in the fastness of all type, while synthetic thickeners were used for the preparation of paste, printing on wool. The highest K/S value was evaluated for the printing paste which was prepared using the polymer-A. The silk samples printed with the paste containing the polymer-A, also have enhanced fastness properties compared to that of using standard thickeners such as guar gum and sodium alginate.

In general, the synthetic polymer thickener performs better than reference thickeners in reactive printing on natural thickeners and therefore the reference natural thickeners can be successfully replaced with the synthesized polymer thickener.

References

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