



Effect of Enzymatic Treatment of Starch Gelatinized with Sodium Hydroxide



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DIFFERENT Kinds of starches were subjected to gelatinization under the action of sodium hydroxide solution at room temperature and treated with alpha-amylase enzyme in the gelatinized form. To achieve this goal, maize starch was subjected to gelatinization using sodium hydroxide at room temperature under different conditions. The latter comprise, starch concentration, sodium hydroxide concentration, pH value, time and temperature as well as the concentration of α -amylase enzyme. The modified starches were evaluated via measuring the solubility and the apparent viscosity at various rates of shear. The modified starches were evaluated as thickeners in printing wool fabrics with acid dye and polyester using disperse dye. The results of these investigations demonstrated that increasing the apparent viscosity by increasing starch concentration is expected. The apparent viscosity increases by increasing the amount of sodium hydroxide. Increasing of α -amylase enzyme concentration is accompanied by a decrease in the apparent viscosity. The most suitable pH for starch modification by enzyme was found at pH 7. The temperature highly influences the apparent viscosity of maize starch at any specific rate of shear. However 50°C is the most suitable degree for modification of maize starch to obtain a suitable viscosity and cold water solubility and also avoid the higher decrease in the viscosity. The treated starches were evaluated via measuring the solubility and rheological properties.

Keywords: Starch, Enzyme, Gelatinization, Sodium hydroxide.

Introduction

Alkali affects structure and physical behavior of starch in solution. The majority of –OH groups in the anhydrous glucose units are ionized at high pH (12.5), so agglomeration of starch chains and paste retrogradation can be retarded⁽¹⁻³⁾.

However, molecular degradation is accelerated by alkali. Thus it is important to find the dissolution condition for minimum degradation, but complete solubilization in alkaline solution⁽⁴⁻⁷⁾.

The degree and product composition from the alkaline degradation are influenced by several reaction parameters, including temperature, nature and concentration of the alkali, and presence of oxygen examined the effect of NaOH concentration on the dissolution of debranched

amylopectin chains (dry sample), and reported that the dissolution was incomplete in 100 mM NaOH. Especially the longer chains (B2 chains) were found to be more difficult to dissolve. Therefore, stronger alkali, e.g. 1 or 2 M NaOH, or KOH is commonly used for starch dissolution for structural analysis. The strong alkali breaks the intermolecular hydrogen bonds of starch, enhancing water solubility⁽⁸⁾.

The effects of starch concentration on gelatinization of⁽⁹⁾ starch in presence of sodium hydroxide (NaOH) were studied in dispersions containing either fixed NaOH/water ratios or fixed NaOH/starch ratio, Microscopic studies revealed that addition of NaOH to a starch dispersion induced immediate and rapid swelling of starch granules at room temperature. On

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heating, granule swelling was more pronounced in presence of NaOH. At high temperature, the granule remnants were smaller and more disperse in presence of NaOH. Dynamic rheological measurements revealed a change in gel properties as the ratio of NaOH/water was increased. The storage modulus (G') showed a c^2 –concentration dependence (where c is the wt% of starch as percentage of the total sample weight), at high starch concentration, in the absence of NaOH. As the NaOH/water ratio was increased, G' decreased for equivalent starch concentration, probably due to the combination of effects of the size and strength of the filler particles, the influence of ionic strength on solvent quality and charge screening, and the hydrolytic effect of NaOH on the starch chains. In the presence of NaOH and at high starch concentration, deviation from the c^2 -dependence were observed. These may be linked to incomplete chemical gelatinization by the NaOH. In dispersions with a fixed NaOH/starch ratio of 5:95 measurements of steady shear (η) and complex viscosities (η^*) were fitted to power law equations and the fitting parameters were then plotted versus starch concentration⁽¹⁰⁾.

The present work is under taken with a view to discover the effect of enzymatic hydrolysis using α -amylase enzyme on different kinds of starches. This was done while starch was in the gelatinized form under the effect of sodium hydroxide solution.

Experimental

Materials

Fabric

Mill scoured wool fabric (100%) supplied by Misr Co. for Spinning and weaving Mehalla El-Kubra, Egypt, was used.

Polyester fabric (100%) produced by spinning and weaving Mehalla El-Kubra, Egypt, was used.

Starch

Maize Starch

Egyptian maize starch supplied by Misr Company for Starch and Glucose, Cairo, Egypt.

Rice Starch

Egyptian rice starch supplied by the Egyptian Starch Yeast and Detergents Company, Cairo, Egypt.

Wheat Starch

Egyptian wheat starch from the local Egyptian Market.

Thickening agents

Mypro gum NP-16, a-nonionic chemically modified Guar endosperm derivative, kindly supplied by Meyhall chemical AG Switzerland, was used.

Daico thick 1600, synthetic thickener was kindly supplied by Daico Company, Cairo, Egypt.

Dyes

Disperse dyes

-Suncron Red S-BLSF, supplied by I.C.I, Cairo, Egypt.

-Dianix Classic Blue BG, supplied by Dystar, Cairo, Egypt.

Acid dyes

-Nylosan Red F-2B, supplied by Sandoz, Switzerland.

-Isolan Bordeaux 2S-B, supplied by Dystar, Cairo, Egypt.

Chemical

Sodium hydroxide, sodium dihydrogen phosphate, formic acid, ammonium sulphate and ethyl alcohol were of laboratory grade chemicals.

Enzyme

Alpha-amylase enzyme, supplied by Novozymes A/S Krogshoejvej 362880 Bagsvaerd Denmark.

Methods

Enzymatic treatment of maize starch using α -amylase enzyme:-

A calculated amount of starch was added to 100ml water and mixed well, different amounts of sodium hydroxide were added under continuous stirring to obtain gelatinous form of starch.

The gelatinized starch was subjected to enzymatic modification via adding amylase enzyme under different conditions. The latter comprise the amount of enzyme, pH, temperature and time to obtain pastes acquired a suitable viscosity, and the rheological properties of the pastes were measured.

After enzymatic modification the modified starch samples were precipitated using ethyl alcohol and finally subjected to purification via dissolving in water and precipitation again in ethyl alcohol to remove the remaining of enzyme.

At this end the modified starches were dried at room temperature.

Preparation of the printing paste

Two different printing pastes were prepared using Acid or Disperse dye as follows:

a- On using Acid dye:

The acid dye paste was prepared according the following recipe:

Dye	30g
Urea	50g
Thioethylene glycol	50g
Thickener	X
Water	Y
Ammonium sulphate 1:2	60g
Oxidizing agent	15
	1000gm

The thickener used was either 80g/Kg printing paste Mypro gum or enzymatic modified starch 120 or 150g/kg printing paste.

b- On using disperse dye:

The disperse dye paste was prepared according to the following recipe:

Disperse dye	40g
Sodium dihydrogen phosphate	5g
Oxidizing agents	5 g
Thickener	X
Water	y
	1000 g

The thickener used was either 30g/Kg printing paste Synthetic thickener (Daico thic) or enzymatic modified starch 120 or 150g/kg printing paste.

2.3. Printing Technique:

- The conventional screen printing technique was used.

Fixation

a- On using Acid dye

Fixation of the printed goods was done by steaming for 30minutes at 100°C with saturated steam.

b- On using Disperse dye

Fixation was carried out by thermofixation of polyester fabrics for 3 min at 180°C.

Washing

a- On using Acid dye

- Washing of the printed goods was carried out as follows:

Rinsing with cold water-

Soaping at 30-40°C in 2g/l soap solution-

Rinsing with cold water-

b- On using Disperse dye:

Washing and reduction clear

Washing of the printed goods was carried out as follows:

-Rinsing in cold water

-Soaping at 60°C with 2g/l Hostapal CV (non ionic detergent) for 20 minutes.

-Reduction clear with 2g/l hydrosulphite, 2g/l sodium hydroxide (32.5%), 2 g/l Hostapal CV (non ionic detergent) at 40-70°C.

-Rinsing at 60-70°C.

-Cold rinsing.

Rheological properties

The rheological properties expressed as apparent viscosity at different rates of shear were measured using Brookfield Model DV-111 Programmable Rheometer.

Fastness properties⁽¹¹⁾

Fastness properties to washing, rubbing (dry&wet), perspiration as well as light fastness were measured according to a standard method.

Result and Discussion

In natural state, starch exists in the form of discrete microscopic granules (2-15µm). The starch granule is composed of linear and branched starch molecules (amylose and amylopectin) associated by hydrogen bonding either directly or through water hydrate bridges to form radially oriented micelles or crystalline areas of various degrees of order. A first step in starch utilization generally is the one that disrupts the granular structure leading to granule hydration, swelling and solubilization of starch molecules, a process referred to as starch gelatinization and is commonly effected by heating the starch granules slurry in water to achieve the adhesive property⁽¹²⁾.

The present work is undertaken with a view to discover the effect of enzymatic hydrolysis using amylase enzyme on different kinds of starches. This was done while starch was in the gelatinized form under the action of sodium hydroxide.

To achieve this goal, different starches were subjected to gelatinization at room temperature under different conditions of sodium hydroxide treatment.

Effect of Starch Concentration

To investigate the effect of starch concentration, different amounts of maize starch 15, 20, 25 and 30g were added to 100ml of water containing 4g of sodium hydroxide, after that the pH was adjusted to pH 7 at room temperature to obtain highly viscous gelatinized mass of maize starch. After that 1ml of α -amylase was added and the temperature was raised to 50°C under vigorous stirring. The mixture was left for 5 minutes at 50°C. After which, the enzymatic modified starches were cooled and its apparent viscosity at various rates of shear were measured according to the method indicated in the experimental section. The results obtained are given in Table 1.

It is clear from the data of Table 1 that as the concentration of starch increases from 15 to 20 to 25 to 30g%, the apparent viscosity increases regularly irrespective of the rate of shear.

On the other hand, at a constant concentration the apparent viscosity decreases (Fig. 1) by increasing the rate of shear.

The dependence of the apparent viscosity to the rate of shear indicates that these pastes are non-Newtonian. While the decreases in the apparent viscosity by increasing the rate of shear indicate that these pastes acquire pseudoplastic behavior.

Increasing the apparent viscosity by increasing starch concentration is expected. Since as the concentration increases the solid content increases and hence the resistance to flow increases.

From the previous data it is clear that the optimum concentration of starch is 20%.

TABLE 1 . Effect of amylase enzyme on the apparent viscosity at different concentrations of maize starch.

Conc. of Starch (g %)	Solubility in cold water	Apparent Viscosity in centipoise at rate of shear (sec^{-1}) of				
		46.5	47.4	48.4	49.3	50.2
15g	Soluble	268	240	199	185	165
20g	Soluble	675	607	512	403	330
25g	Soluble	870	795	677	638	600
30g	Soluble	5108	4229	3781	2818	1917

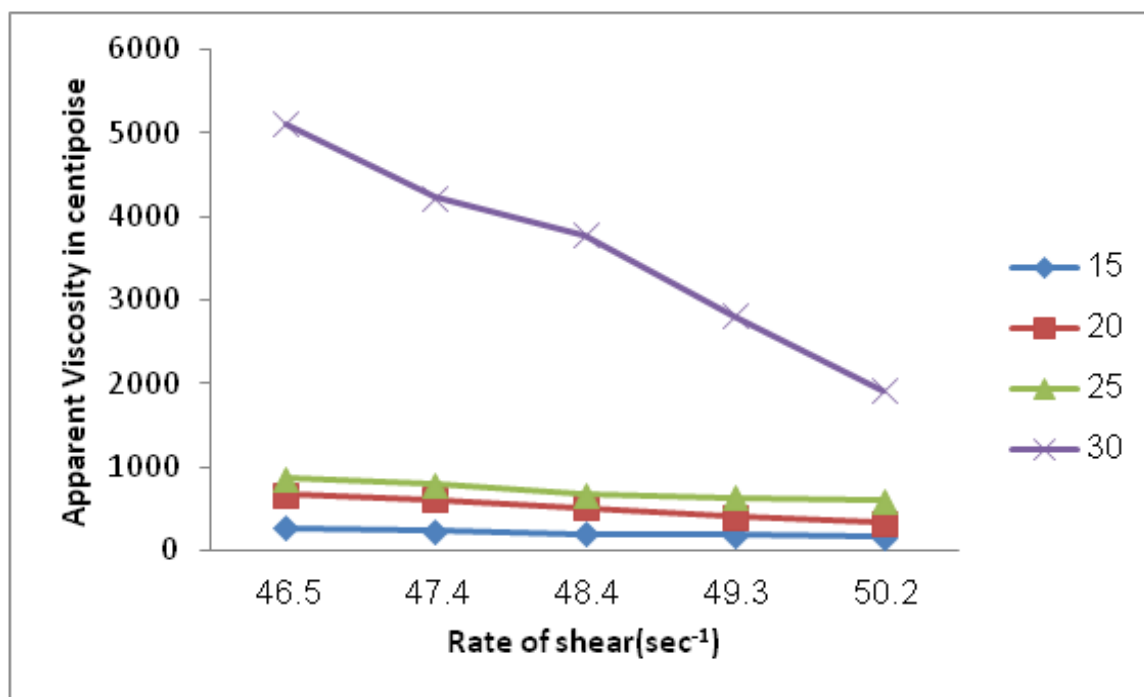


Fig.1. Dependence of the apparent viscosity on the concentration of starch and rate of shear.

Effect of Sodium Hydroxide Concentration:

To investigate the effect of sodium hydroxide concentration, different amounts of sodium hydroxide (3, 3.5, 4 and 4.5g) were added to 100ml water containing 20g of maize starch after that the pH was adjusted to pH 7 at room temperature to obtain a highly viscous gelatinized mass of maize starch. Then 1ml of α -amylase enzyme were added and the temperature was raised to 50°C under vigorous stirring. The mixture was left for 5 minutes at 50°C. After that, the enzymatic hydrolyzed starches were cooled and their apparent viscosities were measured. The results obtained are given in Table 2 and represented in Figure 2.

It is clear from the data of Table 2 that, in spite of the constant amount of starch in the pastes, the apparent viscosity increases by increasing the amount of sodium hydroxide. This phenomenon holds true at any constant specific rate of shear.

Table 2 also clearing that at any specific concentration of sodium hydroxide the apparent viscosity decreases by increasing the rate of shear. The current data also indicates that all of the current enzymatic pastes of starch are characterized by a non-Newtonian pseudoplastic behavior.

Increasing the apparent viscosity by increasing the amount of sodium hydroxide may be due to the effect of sodium hydroxide on the activity of α -amylase enzyme. At low concentration of sodium hydroxide, α -amylase enzyme is more active and hence the rate of enzymatic hydrolysis of starch increases causing a remarkable effect on the viscosity of starch paste as it is clear from the data of Table 2.

From the previous data it is clear that the optimum concentration of sodium hydroxide is 4%.

TABLE 2. Effect of amylase enzyme on the apparent viscosity on using different amounts of sodium hydroxide at constant amount of starch.

Conc. of NaOH%	Solubility in cold water	Apparent Viscosity in centipoise at rate of shear (sec^{-1}) of				
		46.5	47.4	48.4	49	50.2
3g	Soluble	60	41	35	20	16
3.5g	Soluble	541	485	399	282	160
4g	Soluble	675	607	512	403	330
4.5g	Soluble	810	740	635	550	400

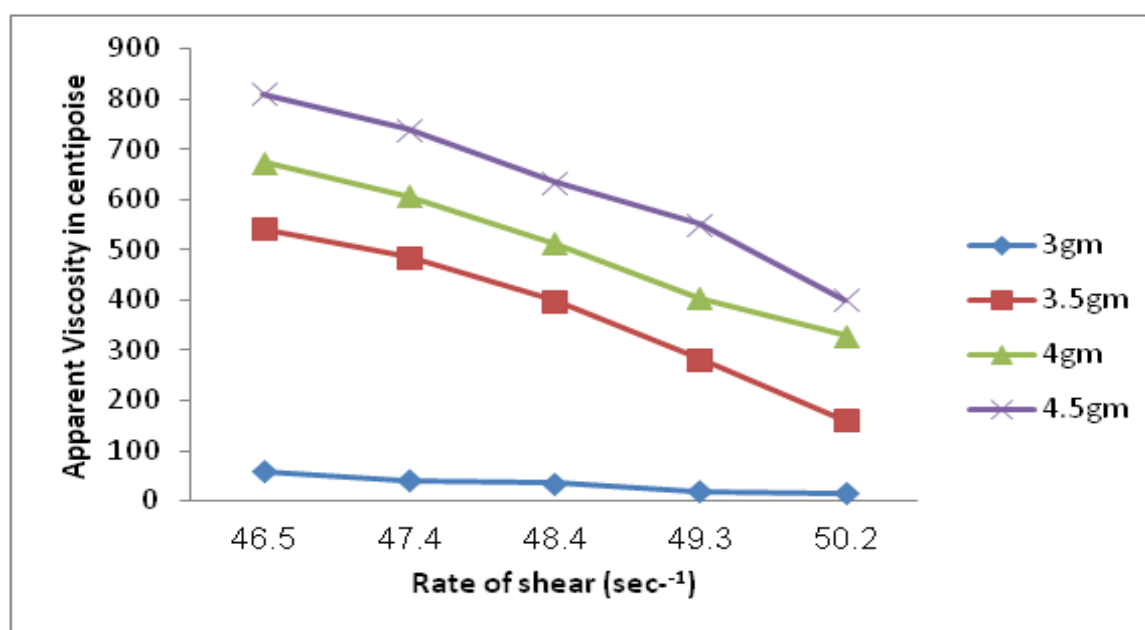


Fig.2 .Dependence of the apparent viscosity on the conc. of sodium hydroxide and rate of shear.

Effect of Enzyme Concentration

To achieve this, 20g of maize starch were added to 100ml water containing 4gm sodium hydroxide mixed well after that the pH was adjusted to pH 7 at room temperature, different concentrations of amylase enzyme (.75, 1, 1.25 and 1.5ml) were added. The temperature was raised to 50°C. The mixture was left at 50°C for 5minutes, after which it is left to cool and its viscosity was measured the results obtained are represented in Table 3 and illustrated in Figure 3.

It is clear from the data Table 3 Figure 3 that the apparent viscosity of the enzymatic modified maize starch depends on both the concentration of amylase enzyme and the rate of shear at which the viscosity is measured.

As the concentration of enzymes increases from .75 to 1 to 1.25 to 1.5ml / 100ml water the apparent viscosity decreases. However, the magnitude of decreasing depends on rate of shear.

On the other hand, as the rate of shear increases the apparent viscosity decreases. For example at 1.5% of enzyme, it decreases from 278 to 255 by increasing the rate of shear from 46.5 to 47.4 sec^{-1} .

Fig.3 Clarify that all the examined pastes are non-Newtonian pseudoplastic solutions, where its viscosity is not constant as Newtonian solutions and decreases by increasing the rate of shear.

The current data is in complete conformance with previous work since it has been reported provided that the substrate concentration is maintained at a high level, and the other conditions such as pH and temperature are kept constant. Thus as the enzymes concentration is increased, so will be the rate of the enzymatic reaction.

From the previous data it is clear that the optimum concentration of amylase is 1ml.

TABLE 3 . Effect of amylase concentration on the apparent viscosity of maize starch.

Conc. Of En- zyme	Solubility in cold water	Apparent Viscosity in centipoise at rate of shear (sec^{-1}) of				
		46.5	47.4	48.4	49.3	50.2
0.75ml	Soluble	1150	985	670	530	470
1ml	Soluble	675	607	512	403	330
1.25ml	Soluble	352	310	289	215	180
1.50ml	Soluble	278	255	204	180	130

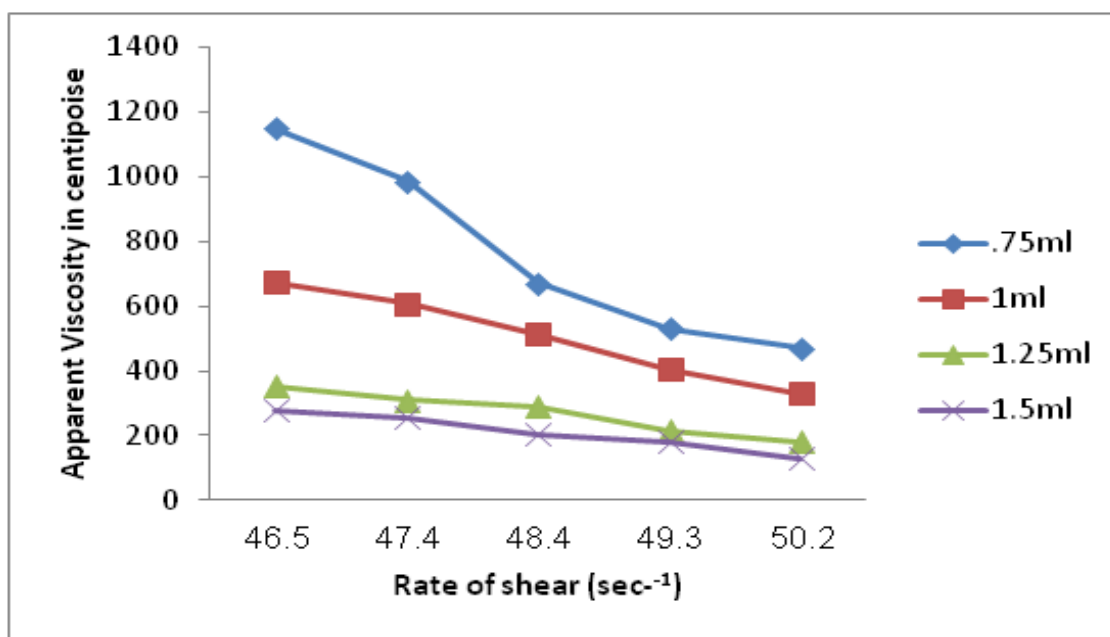


Fig.3. Dependence of the apparent viscosity on the conc. of enzyme and rate of shear.

Effect of pH

The activity of an enzyme depends strongly on the pH of the medium for two major reasons: (1) the presence of essential proton-accepting groups in the catalytic center, and (2) maintenance of the overall structure of the enzyme. Proton accepting groups can be directly titrated and the dependence of enzyme activity on pH often has the form of a bell-shaped titration curve, with a maximum usually in the neutral range (pH optimum). However, the large majority of enzyme have optimum that fall between pH 4 and 8.

To investigate the effect of pH on the rate of hydrolyses of gelatinized maize starch with amylase enzyme. 20g of maize starch were add to 100ml of water containing 4g of sodium hydroxide and mixed well in the high viscous mass. After that pH was adjusted to 5, 6, 7 and 8, then 1ml enzyme was added. The temperature was raised to 50°C. The mixture was left for 5min at 50°C while agitation. The mixture was cooled and its viscosity was measured. The results obtained are given in Table 4 and represented in figure 4.

It is clear from the data of Table 4 and figure 4 that the optimum pH for the current investigation is attained at 7.

TABLE 4. Effect of pH on the apparent viscosity of enzymatic hydrolyses maize starch.

pH	Solubility in cold water	Apparent Viscosity in centipoise at rate of shear (sec^{-1}) of				
		46.5	47.4	48.4	49.3	50.2
5	Soluble	973	866	789	731	698
6	Soluble	898	730	643	590	480
7	Soluble	675	607	512	403	330
8	Soluble	396	302	280	259	215

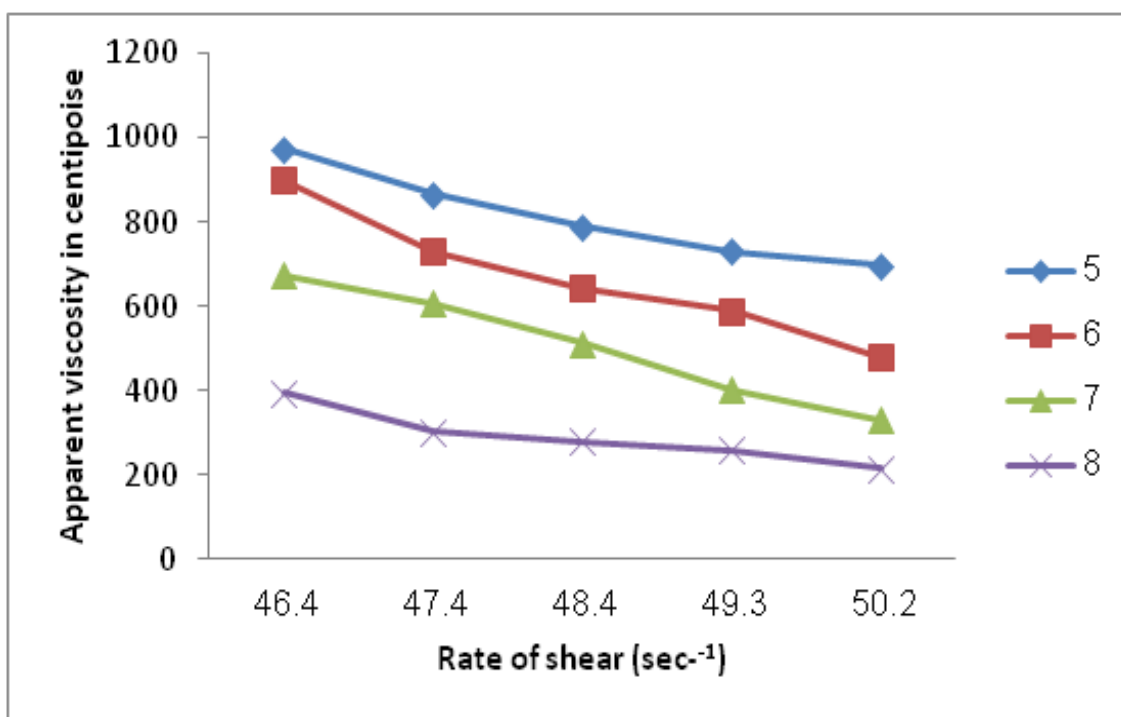


Fig. 4 . Dependence of the apparent viscosity on pH and rate of shear.

Effect of Temperature:

The influence of temperature on enzymes and their activity has been reviewed by several scientists.

All of the above in mind it is of great interest to investigate the effect of temperature on the current work. Hence 20g of maize starch were added to 100ml water containing 4g sodium hydroxide. After that pH was adjusted to 7, then 1ml enzyme was added. The temperature was raised to 45, 47, 50 or 52°C and left at this temperature for 5 minutes. After which, the samples were cooled to room temperature and the viscosity were

measured at different rates of shear. The results obtained are given in Table 5 and represented in Figure 5.

It is clear from the data of Table 5 that the temperature highly influences the apparent viscosity of maize starch at any specific rate of shear.

From the data of Table 5 it is clear that 50°C is the most suitable degree for modification of maize starch to obtain a suitable viscosity and cold water solubility and also avoid the higher decrease in the viscosity.

TABLE 5 . Effect of temperature on the viscosity of enzymatic hydrolyzed maize starch.

Temp	Solubility in cold water	Apparent Viscosity in centipoise at rate of shear (sec-1) of				
		46.5	47.4	48.4	49.3	50.2
45° C	Soluble	2870	2349	1900	1740	1650
47° C	Soluble	1039	977	883	800	737
50° C	Soluble	675	607	512	403	330
52° C	Soluble	400	302	250	190	150

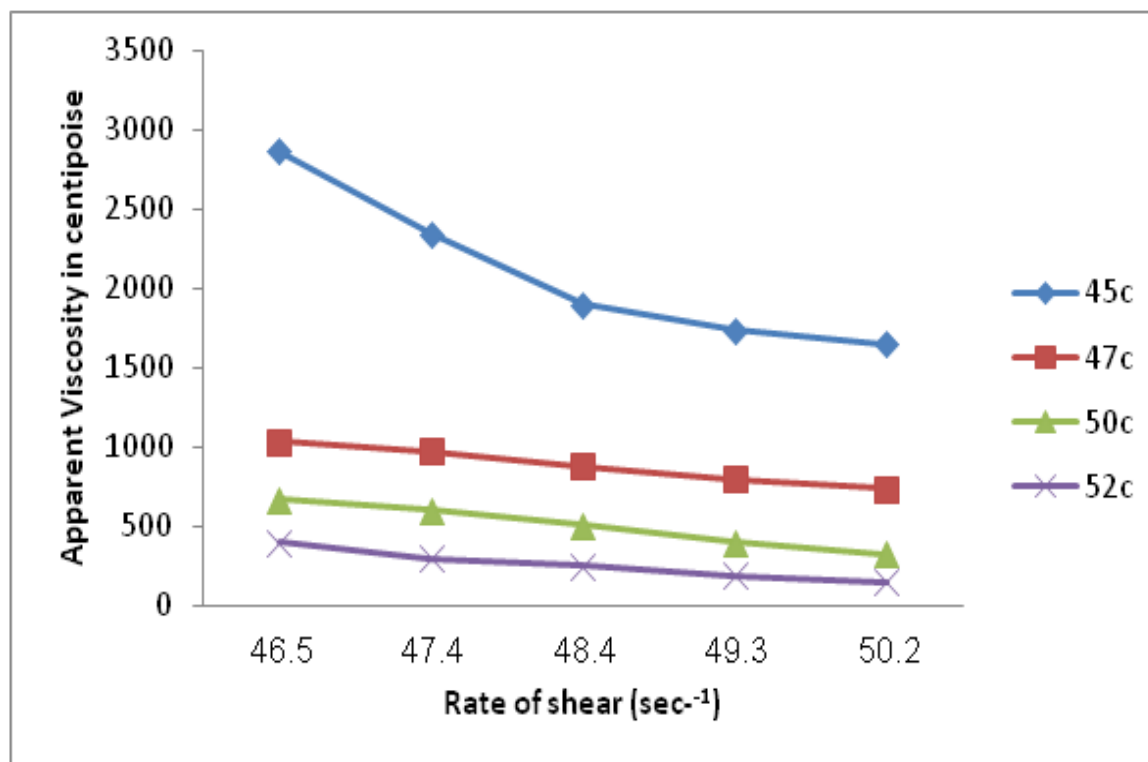


Fig.5. Dependence of the apparent viscosity on temperature and rate of shear.

Effect of Time

It is of great interest to investigate the effect of time of enzymatic hydrolysis of maize starch, to achieve this 20g of starch were added to 100ml water containing 4g sodium hydroxide, after that pH was adjusted to 7, then 1ml enzyme was added. The temperature was raised to 50°C and the mixture was kept for 3, 4, 5 or 6 minutes while the temperature mention constant at 50°C.

After that the mixture was left to cool at room temperature and its viscosity was measured. The data obtained are given in Table 6 and represented in figure 6.

Generally speaking it is clear from the data of Table 6 that as the time of reaction increases the apparent viscosity decreases. This phenomenon is hold true at any specific rate of shear.

Also, here, Table 6 and Fig.6 illustrate that the apparent viscosity depends to the rate of shearing at which it be measured. It decreases by increasing the rate of shear i.e. it is also characterized by a Non-Newtonian pseudoplastic behavior.

From the previous data it is clear that the optimum time is 5min.

TABLE 6 . Effect of Time enzymatic hydrolysis of starch on the apparent viscosity.

Time "min"	Solubility in cold water	Apparent Viscosity in centipoise at rate of shear (sec ⁻¹) of				
		46.5	47.4	48.4	49.3	50.2
3min	Soluble	923	882	777	716	680
4min	Soluble	840	750	605	557	407
5min	Soluble	675	607	512	403	330
6min	Soluble	406	388	340	273	218

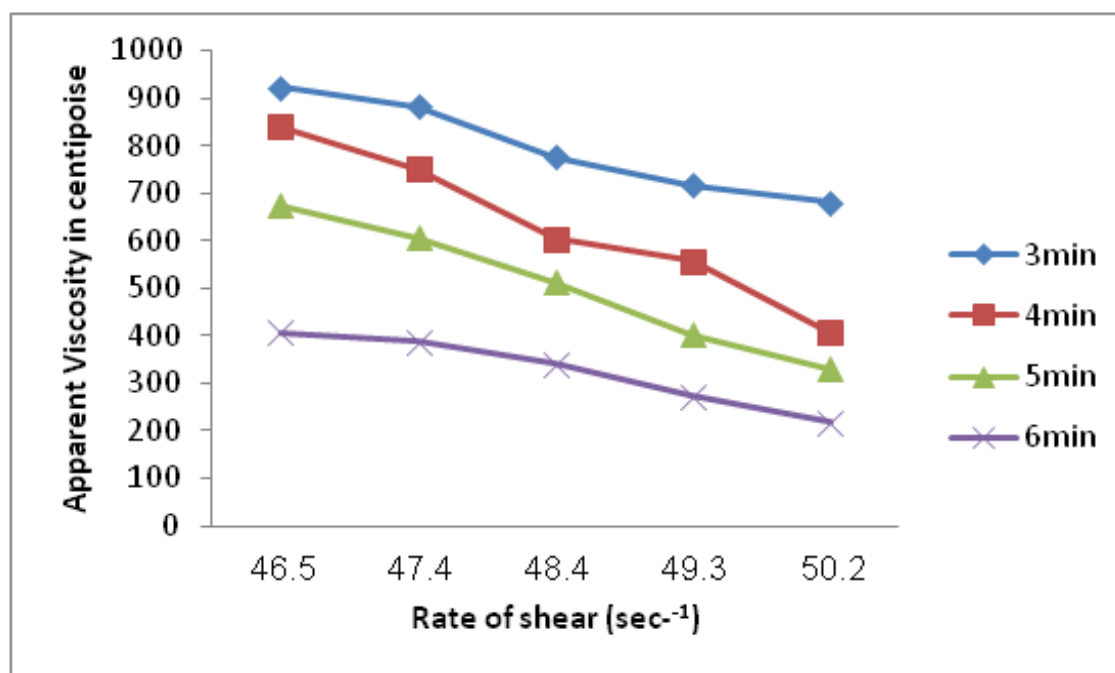


Fig. 6 . Dependence of the apparent viscosity on Time and rate of shear.

Effect of nature of starch

To investigate the behaviour of different kinds of starches towards gelatinization under the action of sodium hydroxide solution in the presence of enzyme. The available three kinds of starches (maize, rice and wheat) were treated under the same optimum conditions.

Hence 20g from every kind of starch (maize, rice and wheat) were added to 100ml water containing 4g sodium hydroxide. After that the pH was adjusted to 7, then 1ml α -amylase enzyme was added. The temperature was raised to 50 °C and left at this temperature for 5 minutes. After which, the samples were cooled to room temperature and the viscosity were measured at different rates of shear. The results obtained are given in Table 7 and represented in Figure 7.

It is clear from Fig.7 that. Irrespective of the nature of starch, the apparent viscosity depends on the rate of shear. As the latter increases the apparent viscosity decreases. Which indicate that these pastes are characterized by non-Newtonian pseudoplastic behaviour.

However it is also clear from the data that the three kinds of starches are different in the values of their apparent viscosity.

Printing

From the previous studies, the optimum condition, were selected. Samples of maize, rice and wheat starches were modified under these optimum conditions and its suitability as thickening agents in printing polyester or wool using disperse and acid dyes respectively. were studied. Given below the details of these investigations comprise the data obtained and its appropriate discussion.

TABLE 7. Effect of nature of starch:

Type of starch	Solubility in cold water	Apparent Viscosity in centipoise at rate of shear (sec ⁻¹) of				
		46.5	47.4	48.4	49.3	50.2
Maize starch	Soluble	675	607	512	403	330
Rice starch	Soluble	300	268	209	172	130
Wheat starch	Soluble	519	475	425	338	218

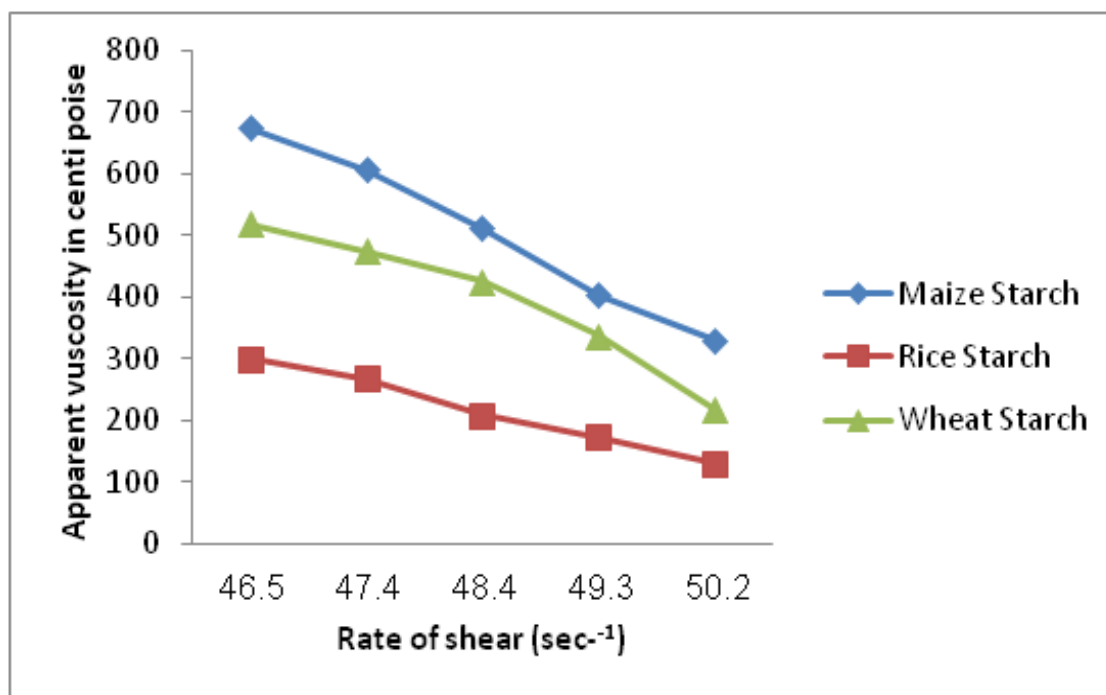


Fig.7. Dependence of the apparent viscosity on Type of starch and rate of shear.

Printing of Polyester Fabric using Disperse dye

To investigate the suitability of α -amylase treated starches in the gelatinized form under the influence of sodium hydroxide. Different starches, i.e. maize, rice or wheat were modified with sodium hydroxide 4g/20 starch in 100ml water at pH 7 followed by addition of 1ml α -amylase enzyme. The mixture was mixed well and the temperature was raised to 50°C. The reaction mixture was left at 50°C for 5 minutes. After that the samples were precipitated in commercial ethyl alcohol, purified in Soxhlet using 75% ethyl alcohol and finally air dried.

The dry modified starches were evaluated as thickening agents in printing polyester fabrics with disperse dye. The printing pastes were prepared according to the recipe indicated in the experimental section. Printing pastes thickened with commercial Daico-thic containing the same ingredients were also prepared and used for the sake of comparison. Samples of polyester fabrics were printed using screen printing technique. After printing, drying and washing the samples were air dried and assessed for K/S and overall color fastness properties. The results obtained are given in Table 8.

TABLE 8. K/S and color fastness properties of polyester fabrics printed using enzymatic treated starches gelatinized NaOH.

Thickening agent	Concentration of thickener	Storing	K/S	Washing fastness		Rubbing fastness		Perspiration fastness			
				St.	Alt.	Dry	Wet	Acidic		Alkali	
								St.	Alt.	St.	Alt.
Dico-thic	2.5%	F	11.74	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		S	9.49	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	12%	F	18.30	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		S	14.51	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
(I)	15%	F	18.11	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		S	15.35	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	12%	F	24.45	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		S	18.76	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
(II)	15%	F	23.46	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		S	20.76	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	12%	F	18.79	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		S	15.95	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
(III)	15%	F	16.67	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		S	15.29	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5

The dye used was disperse dye namely Dianix Classic Blue BG.

St.: Staining Alt.: Alteration

F: Fresh S: Storing 3 days

I: Enzymatic modified Maize starch

II: Enzymatic modified Rice starch

III: Enzymatic modified Wheat starch

It is clear from the data of K/S, that α -amylase enzymatic treated starches could be used successfully as thickening agent in printing polyester fabric with disperse dye namely Classic blue BG, Where, the K/S is nearly equal if not higher in case of using modified starches compared with commercial thickening agent namely Daico-thick. While the color fastness properties to washing, to rubbing or to perspiration remains unaltered.

It is also clear from the data that there is a decrease in K/S of the printed goods on storing for 3 days before commence printing. This phenomenon holds true irrespective of the nature of thickening agent used or its concentration, i.e. for both the commercial Daico-thic. or the modified starches (maize, rice or wheat). The decrease in K/S by

storing may be due to a change in the viscosity of the printing pastes during storing.

The current data also revile that there is a variation between the K/S of the fabrics printed using different kinds of starches. This is expected since the three different kinds of starches are differ in: (a) the molecular weight, (b) the ratio between amylase, amylopectin, (c) the ratio of the amorphous and crystalline regions.

Printing of Wool Fabric using Acid dye

The suitability of the aforementioned enzymatic modified starches in alkali gelatinized form were also investigated as thickening agents in printing wool fabrics with commercial acid dye namely Isolan Bordeayx 2S-B. The results obtained are given in Table 9.

TABLE 9. K/S and color fastness properties of wool fabrics printed using enzymatic treated starches gelatenized.

Thicken- ing agent	Concentration of thickener	Storing	K/S	Washing fast- ness		Rubbing fast- ness		Perspiration fastness				
				St.	Alt.	Dry	Wet	Acidic		Alkali		
				St.	Alt.	St.	Alt.	St.	Alt.	St.	Alt.	
Mypro- gum	3%	F	5.21	4	4	4	4	4	4	4	4	4
	3%	S	3.01	4	4	4	4	4	4	4	4	4
		F	6.38	4	4	4-5	4	4	4	4	4	4
(I)	12%	S	4.72	4	4	4-5	4	4	4	4	4	4
		F	5.88	4	4	4-5	4	4	4	4	4	4
	15%	S	3.71	4	4	4-5	4	4	4	4	4	4
		F	10.44	4	4	4-5	4	4	4	4	4	4
	12%	S	7.76	4	4	4	4	4	4	4	4	4
		F	9.08	4	4	4-5	4	4	4	4	4	4
(II)	15%	S	6.07	4	4	4	4	4	4	4	4	4
		F	8.09	4	4	4-5	4	4	4	4	4	4
	12%	S	6.15	4	4	4	4	4	4	4	4	4
		F	7.01	4	4	4-5	4	4	4	4	4	4
	15%	S	4.60	4	4	4-5	4	4	4	4	4	4
		F	7.01	4	4	4-5	4	4	4	4	4	4

The dye used was acid dye namely Isolan Bordeayx 2s-B

St.: Staining Alt.: Alteration

F: Fresh S: Storing 3 days

I: Enzymatic modified Maize starch

II: Enzymatic modified Rice starch

III: Enzymatic modified Wheat starch

It is clear from the data that, the K/S of the fabrics printed using modified starches is higher than their corresponding samples printed using commercial thickening agent namely meypro-gum.

Storing of the pastes for 3 days before printing cause a slight decrease in the K/S. This may be due to a decrease in the viscosity of the pastes during storing. Hence it does not recommended to store these pastes more than 24 hours before printing.

A breale through the current data revile that there is a variation between the K/S of the wool fabrics printed using different kinds of starches, this can be interpreted as previously mentioned in the case of printing polyester with disperse dye.

Here too there is no difference in the overall color fastness properties for rubbing, for washing or for perspiration, irrespective of the nature of the thickening agent used, its concentration or time of storing.

Conclusion

Different Kinds of starches were subjected to gelatinization under the action of sodium hydroxide solution and treated with alpha-amylase enzyme in the gelatinized form.

The modified starches were evaluated as thickeners in printing wool fabrics with acid dye and polyester using disperse dye. The results of these investigations demonstrated that increasing the apparent viscosity by increasing starch concentration is expected. The apparent viscosity increases by increasing the amount of sodium hydroxide. Increasing of α -amylase enzyme concentration is accompanied by a decrease in the apparent viscosity. The most suitable pH for starch modification by enzyme was found at pH 7. The temperature highly influences the apparent viscosity of maize starch at any specific rate of shear. However 50°C is the most suitable degree for modification of maize starch to obtain a suitable viscosity and cold water solubility and also avoid the higher decrease in the viscosity. It's also clear from the data, α -amylase enzymatic treated starches could be successfully as thickening agent in printing polyester fabric with disperse dye and wool fabrics with acid dye.

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تأثير المعالجة بالانزيمات على النشا المحور في الصورة الجيلاتينية باستخدام هيدروكسيد الصوديوم

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في هذا الفصل تم دراسة تأثير انزيم الفا اميليز في تحلل النشا. تم ذلك بعد تحويل النشا الى الصورة الجيلاتينية (gelatinized) باستخدام هيدروكسيد الصوديوم.

ولتحقيق هذا الهدف تم تحويل نشا الذرة للصورة الجيلاتينية (gelatinized) باستخدام هيدروكسيد الصوديوم على البارد تحت ظروف مختلفة اشتملت هذه الظروف على دراسة تأثير كل من تركيز النشا، تركيز هيدروكسيد الصوديوم، الأس الهيدروجيني للخليط، الزمن، درجة حرارة المعالجة بالإضافة الى دراسة تأثير تركيز انزيم الفا اميليز وتم تقييم نتائج تلك المعالجة الحيوية بالانزيم عن طريق قياس الذوبان في الماء البارد وكذلك تقدير قيم اللزوجة الظاهرية عند معدلات القص المختلفة.

هذا وقد اشتملت الدراسة على دراسة امكانية استخدام النشويات المحضرة كمتخانات في طباعة اقمشة الصوف باستخدام صبغات الفصيلة الحامضية وكذلك طباعة اقمشة البولستر باستخدام صبغات الفصيلة المشتته.

ويمكن تلخيص اهم النتائج التي تم التوصل اليها في هذا الفصل فيما يلي:-

- ١- تزداد اللزوجة الظاهرية بزيادة تركيز النشا.
- ٢- تزداد اللزوجة الظاهرية بزيادة كمية هيدروكسيد الصوديوم المستخدمة في عملية تحويل النشا الى الصورة الجيلاتينية.
- ٣- زيادة تركيز انزيم الفا اميليز يكون مصحوبا بنقص في اللزوجة الظاهرية عند ثبوت معدل القص.
- ٤- انسب اس هيدروجيني لتحويل النشا بالانزيم كان عند اس هيدروجيني ٧.
- ٥- تلعب درجة الحرارة دورا كبيرا على اللزوجة الظاهرية عند اى معدل قص وعلى اى حال فان درجة ٥٥٠ درجة مئوية يمكن اعتبارها الدرجة المثلى في تحويل نشا الذرة بانزيم الاميليز للحصول على نشا قابل للذوبان في الماء البارد ولزوجة مناسبة للطباعة.
- ٦- كلما زاد زمن المعالجة قلت درجة اللزوجة.
- ٧- بغض النظر عن نوع وطبيعة النشا المستخدم فإن الظروف المثلى لتحويله بهذا الاسلوب للحصول على منتج قابل للذوبان في الماء ويتميز بلزوجة مناسبة هي عندما يكون تركيز النشا ٢٠ جرام وكمية الماء ١٠٠ مللي وهيدروكسيد الصوديوم ٤ جرام مع اضافة ١ مللي انزيم الفا اميليز وضبط الاس الهيدروجيني عند ٧ وتقليب الخليط جيدا مع رفع درجة الحرارة الى 50٠ درجة مئوية وتركه عند هذه الدرجة لمدة ٥ دقائق.
- ٨- تتميز عجائن النشويات المعالجة بالانزيم بهذه الطريقة بخواص ريولوجية غير نيوتينية من النوع البيسيدوبلاستيك.
- ٩- عند طباعة اقمشة البولستر باستخدام الصبغة المشتته (Classic blue BG) فان شدة يساوى تقريبا ان لم يكن اعلى في حالة استخدام النشويات المحورة مقارنة بالمتن التجاري (Daico thickener).
- ١٠- يتضح من خلال النتائج انخفاض شدة اللون للعينات المطبوعة للعجائن المخزنة لمدة ثلاثة ايام، هذه الظاهرة صحيحة بغض النظر عن طبيعة وتركيز المتن المستخدم سواء كان المتن التجاري daico-thic او النشا المحور (الذرة، الارز، القمح). وقد يكون الانخفاض في شدة اللون بسبب التغير في اللزوجة نتيجة التخزين.
- ١١- وعند طباعة الاقمشة الصوفية باستخدام الصبغة الحامضية (Isolan Bordeayx 2S-B) فان شدة اللون للاقمشة المطبوعة باستخدام النشا المحور كانت اعلى من الاقمشة المطبوعة باستخدام المتن التجاري (mypro gum).
- ١٢- تخزين معجون الطباعة لمدة ٣ ايام قبل الطباعة يسبب انخفاضا طفيفا في شدة اللون. قد يكون هذا بسبب انخفاض في لزوجة معجون الطباعة اثناء التخزين وبالتالي فانه لا ينصح بتخزين هذه المعاجين اكثر من ٢٤ ساعة قبل الطباعة.
- ١٣- كما يلاحظ ايضا عدم وجود فرق في خصائص ثبات اللون والاحتكاك والغسيل والعرق بغض النظر عن طبيعة المتن وتركيزه او وقت تخزينه.