Studies on Synthesis and Properties of Urea formaldehyde Adhesives

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Summary: A low cost synthesis of urea formaldehyde adhesive from local raw materials was developed. Urea (100g) was dissolved in 37 % formalin (150ml) and transferred to flask. With NaOH solution, the pH was adjusted to 8.5 and refluxed for two hours on water bath until required viscosity was obtained. The viscosity (180-280cps), solid contents (45-63 %), density (1.80-2.25g/ ml), pH (7.0-8.5) and shelf life (4-115 days) were measured to judge the level of quality. The parameters: viscosity, density, solid contents, appearance and pH were found to be compatible with the standard values. Moderate pot-life and tensile strength on application to wood were found to be encouraging.

Introduction

An adhesive in a broad sense is a substance which can bind two surfaces together by adhering them strongly [1]. Adhesives find their frequent application because they weld two surfaces rapidly. For this reason a variety of adhesives are used for this purpose.

Urea formaldehyde adhesives are thermosetting, when heated; they become thermo-plastics and set to an infusible and insoluble mass. Belonging to the amino-resin category, they find wider applications and greater scope in research studies. John and Pollack [2] were among the first to study the synthesis and application of urea-formaldehyde as resins. Urea formaldehyde is available in the form of solutions (45-67 % solid contents) also called urea glues. These are condensation products of urea and formaldehyde. Molar ratio of urea to formaldehyde, pH of the solution, temperature of reactants, concentration of reactants and time of reaction are the factors that govern the quality of product formed [3]. Thus a variety of urea formaldehyde adhesives can be prepared [4, 5]. Urea formaldehyde glues have very good resistance to cold water, fair resistance to warm water and negligible resistance to hot water; however it can be improved by melamine or resorcinol. Addition of melamine formaldehyde or resorcinol formaldehyde may further upgrade the product.

Now there is dire need to improve the standard and quality of urea formaldehyde in the country to help industrial sector because Pakistan has not attained a fairly diversified base in the industrial sector.

In Pakistan, the production of urea formaldehyde was started in 1968 and it has been mainly used as adhesive for plywood. The present work is aimed to develop a suitable method for synthesis of urea formaldehyde adhesive from indigenous resources, its color, durability and resistance to the environmental conditions may be compatible with imported adhesives

Results and Discussion

In general an adhesive for wood-to-wood surface should be cheap, quick in action and excellent in quality. It should be capable of being cured at relatively lower temperatures. It gathers attraction for its application if it is resistant to moistures, solvents, heat and micro organisms.

Urea formaldehyde adhesive has several advantages over the other types of adhesives. Although durability of this adhesive is less but the durable ones available in the market are very expensive. The urea formaldehyde adhesive was prepared by varying amounts of urea (50-100 mg) and formalin (100-200 mg) in different samples. Similarly, the control of pH and rate of polymerization were catalyzed with lactic acid, citric acid, sulfuric acid, ammonium chloride and formic

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Table-1: Various Samples of Urea Formaldehyde Adhesive Prepared.

Sample Character	A	B	C	D	E	F
Urea (g)	50	100	100	100	100	100
Formalin (ml)	100	200	200	200	200	150
Base (1-2N)	NaOH	NaOH	NaOH	NaOH	NaOH	NaOH
Acid as catalyst	Lactic acid	Citric acid	Sulfuric acid	NH_4Cl	H_3PO_4	Formic acid
Stabilizer	----	----	NH_4OH	NH_4OH	NH_4OH	----
Solid contents (%)	55	58	59	63	45	58
Pot life (days)	20	15	25	04	115	30
Viscosity (cps)	180	195	225	280	180	180
Density (g/ml)	1.8	1.85	2.25	1.15	1.90	1.95
Time of heating (minutes)	75	65	75	100	90	250

Table-2: Standard Values for the Properties of Urea Formaldehyde Adhesive.

Properties	Viscosity (cps)	Density (g/ml)	Appearance	pH	Solid Contents (%)	Pot life (days)
Standard Values	200-300	1.260-1.262	Transparent to milky	7.5-8.0	~60	60

acid as acid catalysts and NaOH as base for all samples given in Table-1.

These results revealed that life for sample E was the highest (115 days) while viscosity 9180cps) and tensile strength were lower. Samples A, B and C had very low shelf life (15-25 days). However, appearance, viscosity, pH value and percentage of solid contents were compatible with those of standard values given in Table-2 [6]. Sample D's viscosity is nearest to the upper limit of standard values as compared to other samples. But the shelf life of sample D was only four days that leaves insufficient time for its proper application. Sample F possessed appearance, viscosity, pH value, density and solid contents comparable with standard values. It has sufficient shelf life up to one month to avoid any hardening of adhesive before its application.

The application of the sample F was studied. The assembled pieces of wood pressed over night showed great and admirable tensile strength. The use of local raw materials and lower consumption of formalin resulted in phenomenal reduction in production cost that was certainly an encouraging achievement while in the previous work [7], more quantity of formalin was used in the preparation of urea formaldehyde. However, further research work may lead to better results that may help in cheaper and higher polymerization rates to achieve industrial goals.

Experimental

Urea (50 mg) was taken in a flask and dissolved in 100ml formalin. The pH was adjusted (8.5) by adding NaOH (1-2 N) solution. The whole solution was refluxed for an hour to increase the rate of reaction. After this pH was lowered (5.5) by using lactic acid solution to increase the rate of polymerization.

The solution was refluxed further until desired viscosity of the product was achieved. The pH was then raised to 8 with NaOH solution. The adhesive thus prepared was applied on plywood to note its efficiency.

Six samples of urea formaldehyde were prepared by using the same procedure, and varying the amount of urea and formalin at different pH values. Time of reflux and acid for lowering the pH was also altered in different samples to note their effects on quality of urea formaldehyde thus prepared.

Viscosity, density, pH value, shelf life and percentage of solid contents in urea formaldehyde adhesive were determined according to standard methods [8].

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