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Manufacture of Adhesive from CIC Polymerizing Paint Waste

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Abstract- *The waste material in paint industry is produced during the process of cleaning of the reactors with water and detergent. It is mainly coagulated of homo-polymers and copolymers of methyl acrylate, ethyl acrylate, Butyl acrylate, Hexyle acrelate, vinyl acrelate and styrene. For blends of acrylate copolymer homo-polymers and copolymers and Poly vinyl acrylate are contained in this waste sludge. Surfactants used during polymerize and non-ionic (Poly ethylene oxide) Acryl ether sulphate etc. Paper adhesive was prepared from that waste and pressure-sensitive adhesive (PSA) properties, such as peel adhesion and holding power were examined. The values of peel adhesion were dramatically reduced by reducing moisture content of the sludge. However, all blends had a high holding power without adding plasticizer. Since the PVA base adhesive is more expensive, wheat flour was mixed with sludge and tested value of peel adhesion. Then peel test could be increased and holding power not is required.*

1. INTRODUCTION

Paint manufacturing is a branch of chemical industry, which uses several raw materials to produce paint. Solvent based paint manufacturing plants produced hazardous waste. This paper examines to produce by product from waste sludge from CIC Paint Company at Rathmalane, in Sri Lanka. The waste sludge is generating at waste treatment stage which is neither can be treated nor discharged to the environment [1]. Therefore, the aim was to make a valuable product by using it. Large companies frequently recycle some of their wastes on site, while small companies send their waste off site to be recycled [2,3]. Initially, lab tests were done to identify characteristic of sludge. Mainly sludge is contained *Poly vinyl acetate* and *Poly acrylic*. It has 70-80% of moisture. According to characters of the waste preparation of an adhesive is more suitable [4]. Initially Pressure sensitive adhesive was prepared. Pressure sensitive adhesive (PSA) tapes composed of acrylic copolymers have been extensively utilized in various industries, such as packaging, printing, electrical insulation, and automobile [5]. In general, the PSA properties (tack, peel adhesion, holding power) of acrylic adhesive have been controlled by blending tackifiers or dissimilar polymers, by adjusting molecular weight and its distribution, and by copolymerization with a polar monomer and curing system.

Polyvinyl acetate (PVA or PVAc) is a rubbery synthetic polymer. As an emulsion in water, PVA is sold as an adhesive for porous materials, particularly wood, paper, and cloth. It is the most commonly used wood glue, both as "white glue" and the yellow "carpenter's glue." PVA is widely used in bookbinding and book arts due to its flexibility, and because it is non-acidic, unlike many other polymers [6]. More, Polyacrylic can be used as thickening agents and coatings. Many acrylic resins are used for binding cloth, plastics, leather and in some cases metal foil [7].

When consider all these properties of both polymers, an adhesive is the most suitable product from this sludge. Therefore, preparation of adhesive formular and several adhesive tests were carried out at university laboratories. However, adhesive tests for wood and metal can't be done under these facilities. Hence, adhesive was prepared and tests for paper and cardboard.

A pure PVAc emulsion without any plasticizer will, upon aging, become hard and brittle. However, the addition of the proper amount of plasticizer will soften it and eliminate embitterment with age [8]. Therefore, a smaller amount of plasticizer added to the PVAc formulation must be kept within the proper limits to ensure the integrity of the product. An amount of plasticizer is kept below 15%.

In this paper, described how paper adhesive prepare from waste sludge and tests carried out to enhance bond strength. The effect of blend of polymers (poly vinyl acetate and poly acrylate) content on PSA properties was also investigated for the blends. Then, the mechanism of reduced PSA properties was explained via dynamic chemical properties.

2. MATERIAL AND METHOD

2.1 Raw material

Raw material employed in the experiment was waste sludge at CIC Company at Rathmalana and Chemicals used for this project are borax, copper sulphate, petroleum ether, and isopropyl alcohol and wheat flour.

2.2 Apparatus

Tensile testing machine

This can supply a tensile force with a constant rate of grip separation. The machine shall be equipped with a force-measuring system complete with an indicator and/or a recorder. The indicated force shall not differ from the true applied force by more than 2 %. The response time of the machine shall be short enough not to affect the accuracy

with which the force applied at the time of rupture can be measured. The force at rupture of the specimen shall lie in the range between 10 % and 80 % of the full-scale reading.

Moisture balance was used to change the moisture level of the sludge. Characters of sludge were measured using oven, muffle furnace and balance.

2.3 Testing Method (180^0 peel testing)

To test our samples, peel testing method was used and a 180° peel test for the determination, under specified conditions, of the peel resistance of a bonded assembly of two adherents. A 90° peel test, more suitable for use with less flexible adherents that crack, break or delaminate in the 180° peel test, is described in ISO 8510-1. A bonded assembly of two adherents is prepared using the adhesive under test (Figure 1). The adherents are pulled apart at a substantially steady rate, starting at the open end of the bond; in such a way that separation occurs progressively along the length of the bonded adherents. The force is applied substantially perpendicular to the plane of the bond, through the separated part of the flexible adherent.

Figure 1: A bonded assembly of two adherents

2.4 Characteristics of sludge

Total alkalinity	= 336
pH	= 9.63
density	= 952.13 kg/m3
Moisture content	= 88.87%
Solid content	= 11.13 %
Volatile solid	= 6%

2.5 Test specimens: Adherents

The adherents shall be thick enough to withstand the expected tensile force and their dimensions shall be measured accurately and reported in full in the test report. The recommended thicknesses of test specimens are: metals 1, 5 mm; plastics 1, 5 mm; wood 3 mm; compounded rubbers 2 mm. Other thicknesses agreed on between the purchaser and the supplier of the adhesive may be used [10].

2.5.1 Rigid adherent

The rigid adherent shall consist of a strip of flat material of width 25, 0 mm ± 0, 5 mm and minimum length of 200 mm.

2.5.2 Flexible adherent

The flexible adherent shall be capable of being bent through an angle of 180° without gross irreversible Dimensional change. Unless specified otherwise, the flexible adherent shall be not less than 350 mm in length. Its width shall be either

a) The same width as the rigid adherent, or
b) For materials, prone to fraying.

2.6 Preparation of test specimens

The procedure used in preparing the test specimens shall be such as to minimize variations. The use of a pneumatic or hydraulic press, hand or power-operated, that can apply a pressure of up to 1 MPa, is recommended [9]. Surface treatments shall be in accordance with ISO 17212, or, if this is not feasible, in accordance with the manufacturer's instructions. Apply the adhesive, in accordance with the manufacturer's instructions, over the whole width of the adherents to a length of 150 mm on each adherent. Allow the adhesive to set and, if necessary, cure it, in accordance with the manufacturer's instructions. Bond the adherents using the method recommended by the manufacturer of the adhesive.

If a press is used to make the test specimens, it shall can apply an even pressure over the entire bonded area and should preferably be fitted with a timer-controlled release mechanism. In order to provide a uniform distribution of pressure over the bonded area, the platens of the press shall be parallel. When this is impracticable, one platen shall be covered with a resilient pad. A 10-mm thick pad of rubber of Shore A hardness approximately 45 has been found to be satisfactory, using a press that applies a pressure of up to 700 kPa. As an alternative to preparing individual test specimens, panels of suitable size may be bonded to each other and test specimens cut from the bonded assembly, discarding from the bonded assembly the 12-mm strip along each of the outer edges parallel to the longer sides of the test specimens. Determine the average thickness of the applied adhesive as accurately as practicable, by weighing or another suitable technique. A minimum of 5 specimens shall be tested.

2.7 Procedure

Bend back the unbounded end of the flexible adherent. Clamp the rigid adherent in the fixed grip and the flexible adherent in the other grip, taking care that the test specimen is accurately positioned between the grips so that the

tension applied is distributed uniformly across the width of the test specimen and set the machine in motion at a constant rate of grip separation. The recommended rate of grip separation is 100 mm/min - 10 mm/min. Record the rate of grip separation. Also record the force as a function of grip separation, Continue the test until at least 125 mm of the bonded length has separated.

3. RESULTS AND DISCUSSION

Figure 2: Grip Separations

For each specimen, determine from the curve of force versus grip separation, the average peel force in Newton, over a peel length of at least 100 mm, but not including the first 25 mm. This may be done by drawing an estimated average line (see Figure 2) or by planimetry, or by another suitable means if a more accurate result is required. Record the maximum and minimum force in this range. Calculate the arithmetic mean of the average peel forces for all the specimens tested, as well as the arithmetic means of the maximum and minimum forces.

3.1. by varying moisture Content of the sludge

In this case several analyses were carried out by using the sludge by varying the chemical composition. Initially, the moisture composition was changed in the sludge and subject to peel test. The test results are shown in Table 01.

Table 1: Tensile test results

Sample	1	2	3	4	5
Moisture %	70	60	50	40	30
Tensile Strength (N)	3.23	1.68	1.42	1.02	1.13

Adhesive quality can be increased with moisture content without adding any plasticizer [11]. But pressure must be applied to stick the pieces (chart 01).

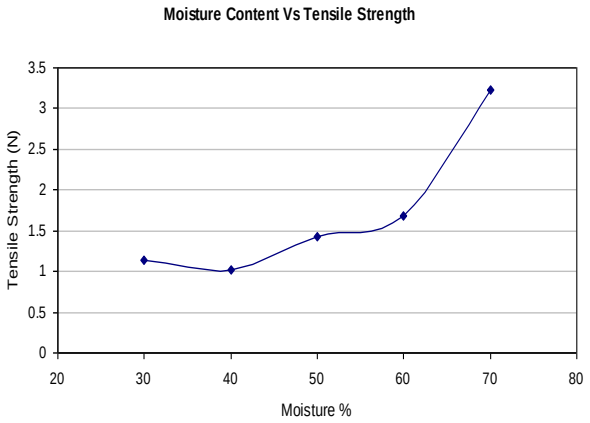

Chart 1: Variation of tensile strength with moisture

3.2. By adding the constant wheat sample to the sludge

Wheat to sludge ratio varied from 2:1 to 2:5. As in Table 02 tensile strength was increased with the sludge percentage up to 50%. Thereafter it was started to reduce again as shown in Chart 2.

Table 2: Tensile strength of wheat samples

Wheat Sample (ml)	Sludge	Tensile Strength
20	10	5.21
20	20	6.76
20	30	6.31
20	40	6.31
20	50	6.04

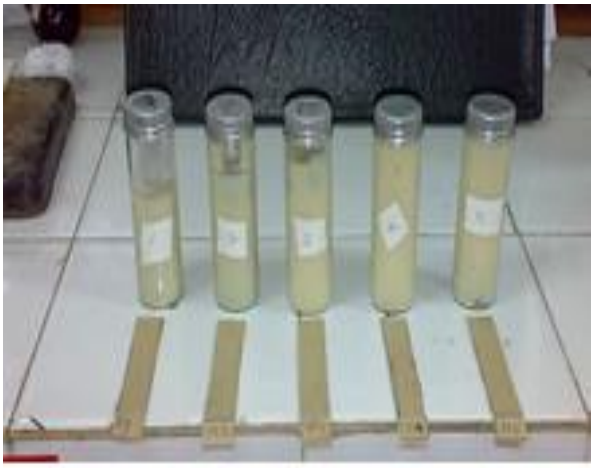

Figure 3: Wheat samples

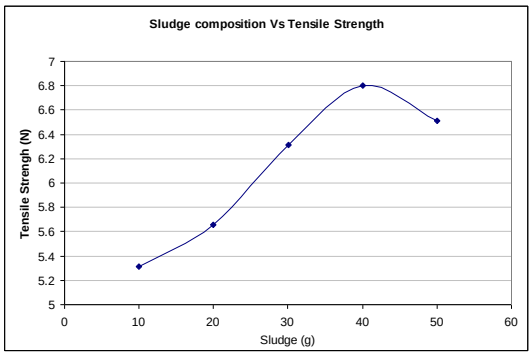

Chart 2: Comparison of sludge composition and tensile strength

3.3. by adding vary wheat sample to the sludge

In third test added varying wheat sample to get knowledge of best ratio for the adhesive as presented in Table 03.

Table 3: Tensile strength with adding different wheat samples

Wheat Sample (ml)	Sludge	Tensile Strength
5	10	5.57
10	10	3.98
15	10	5.29

Optimum wheat to sludge ratio is 1:2. Wheat sample has prepared by adding 500ml water with 100g of wheat flour and 2g of copper sulphate. Boil it up to 70 ^{0}C (Chart 3).

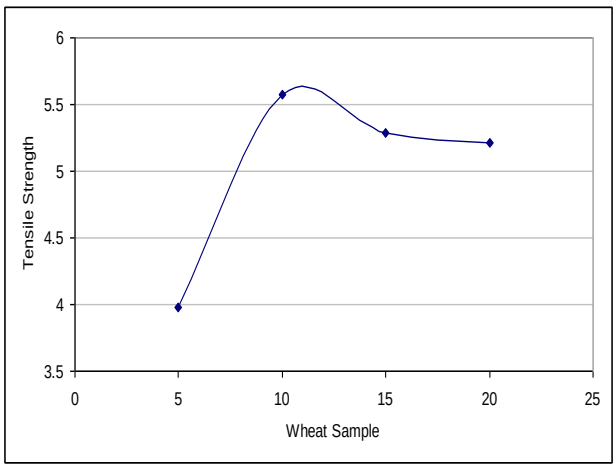

Chart 3: Tensile strength when varying wheat sample

3.4. Tensile strength with time

Tensile strength was measured with time as described in table 04.

Table 4: Tensile strength of samples

Time (day)	Sample tensile strength	
	Pre-sample	With borax
1	1.33	1.64
2	2.25	2.72
3	3.02	2.92
4	3.82	3.01
5	4.67	3.8

Tensile stresses were increased with time without adding wheat by pressing samples which is shown in Chart 4.

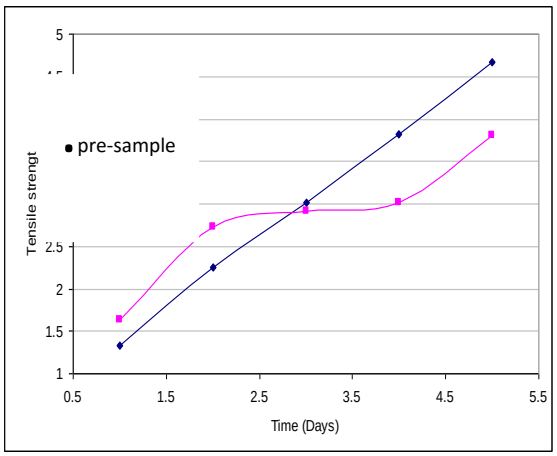

Chart 4: temporal change of tensile strength

4. CONCLUSION

Paper Adhesive was investigated form waste sludge of CIC Company which contain PVA and Poly Acrylate. The values of peel adhesion were dramatically increased with moisture content. Optimum moisture content for sludge is 70%. With time tear resistance was increased. The mechanism of reduced PSA properties was investigated through adding wheat flour and heat up. After wheat flour was added pressing is not needed and higher tear force was required to separate two pieces. Optimum wheat to flour ratio is 1:2. Further experiments can be carried out by adding this sludge with poly vinyl base adhesive component.

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