Production and Study of Factors Affecting the Flexibility of Polyester Paint Using Local Materials

By

Dr. Opara C.C.
Sokore Bekere
Ugwo Prince Nwenendah
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Dr. Opara C.C.1*, Sokore Bekere2, Ugwo Prince Nwenendah3

1 University of Port Harcourt, Department of Chemical Engineering, 2,3 School of Graduate Studies, University of Port Harcourt, Department of Chemical Engineering.

Email: drccopara@yahoo.com, Email: nweneprince@yahoo.com

Abstract

The most important functional property of polyester paint is the flexibility. In this study paints were formulated from local raw material and factors influencing their flexibility were investigated, these factors include the amount and percentage of urea-formaldehyde in the paints. The quantity of the urea-formaldehyde was varied from 100- 300g/litre in the paint. Flexibility drying time, 0-T and I-T bend test were carried out. It was observed that the formulation that had 100 – 180g/litres passed both 0-T and I-T test with a drying time of 120 and 98 minutes respectively, the other paint of 250 – 300g/litres failed the above test but has a fast drying time of 50,30 and 10 minutes.

Keywords: Polyester, Paint, Urea Formaldehyde, Flexibility, Resins.

INTRODUCTION

Polyester Paints are basically paints that are formulated from oil-free unsaturated polyester resin. They are based on condensation polymerization of diacids such as ophthalmic anhydride, aliphatic diacids and atipic acids which promote extensibility, flexibility and polyhydric alcohols such as trimethyl propane.[1]. They are characterized by right solid content (non-volatile matter in the coating component), colour stability and easy application. In polyester paint, the balance between hardness and flexibility is controlled by careful selection of the prime constituent. The high molecular weight left behind after curing or drying provides the film properties in polyester coating. High molecular weight linear polyesters may be used as physically drying binder components in paints, although the majority of uses are in baking enamels for highly flexible coatings, such as coil and can coatings in combination with amino resins or other suitable hydroxyl–reactive cross-linkers.[2]. Paints consist essentially of pigments dispersed in a resinous binder reduced to an acceptable viscosity with a solvent. One or more additives may be incorporated to modify one or other of the film properties of the paint. The binding medium or binder which in most cases is organic is the most important components in the majority of paint, determine the physical and chemical properties of the paint. Wetting agents are used to facilitate the dispersion of the pigment to keep the pigment in suspension during storage of paint and to pressure the homogeneity of pigment mixture while the paint is drying.[3]

1.1 MOLECULAR WEIGHT AND CHEMICAL STRUCTURE

Generally, resins have to obtain certain molecular weight before they can have useful mechanical properties and this molecular weight necessarily depends on a large measure on chemical structure. The flexibility of the film generally improves with increase in molecular weight of the polyester resin. The flexibility of a linear polyester resin and the segment between cross-link in cured product is decreased by the presence of polar group and regularity in the molecular structure. A non-polar irregular long chain monomer should be of greater flexibility containing highly flexible chain, soft, non-brittle with relatively high resistance to impart and to tear. The chemical nature of the resins in the polar group along the macro chain (COOH of CONH₂) of the resins and the average chain length up to the polymerization range of about 4000 to 5000 has some profound influence in the flexibility of some resins.
Low molecular weight polyesters range from 500 to 7000 g/mol and are, in general, not suitable as physically drying binders. [4]. Because of their low degree of polymerization, they carry a great many functional terminal groups [1]. Low molecular weight polyesters may be linear or branched; by variation of the manufacturing process, it is possible to incorporate mostly either hydroxyl or carboxyl end groups, or both kinds. By themselves, low molecular weight polyesters are not satisfactory film formers. They require a reaction partner capable of reacting with the end groups of the polyester and causing the formation of a cross-linked, duroplastic film. [5] Amino resins [6] and polyisocyanates [7]-[8] and are suitable as such cross-linking agents for hydroxyl polyesters, whereas epoxy resins and polyoxazolins [9] may be used for carboxyl polyesters. By proper selection of the reactants, the formulator can design products ranging from two component or one-pack solvent-borne enamels with amino resins or blocked polyisocyanates to powder coatings or, via the salt formation of carboxyl polyesters, water-soluble stoving paints.[10]-[11]

1.2 MECHANICAL PROPERTIES OF PAINT FILM

Mechanical properties are of fundamental interest, although other properties such as flame resistance, thermal stability and chemical resistance are of concern in more specialized application. All paint or varnish regardless of use, must exhibit a specified range of mechanical properties suitable for that application. Some of interest to paint formulator and manufacturer are tensile, compressive and flexical strength, and impart resistance are most important. In all cases they are a measure of how much stress a sample can withstand before “fail”.

1.2.1 FLEXIBILITY

Flexibility means capable of being turned or twisted without being broken and with or without returning to its former shapes or it is the ability of paint to withstand both tensile and compressive stress.

Paint and varnish film must have sufficient elasticity so that they do not split or crack following upon shrinkage of the film or movement of the substrate due to weather or service condition. The flexibility of film may be evaluated by examination of unsupported films and by elongation of bending of coated panel.

1.2.2 POLYESTER RESIN

Polyester resin is normally reserved for oil free acid or hydroxyl functional polyester. Typically they are derived from di or polyhydric alcohols reacted with di or tribasic acid or anhydride dissolved in a solvent.

There are basically two types of polyester depending on the ratio of acid to polyols used in the preparation. They may have predominance of hydroxyl groups or of acid group. These groups are the sites for cross-linking reaction example with formaldehyde resin or reactive Isocynates in case of hydroxyl group or solid epoxy resin in case of the acid group.

MATERIALS AND METHODS

In this study, the materials, equipment and method involved in the formulation of polyester paint flexibility are described below.

Materials – the material required for production of polyester paint include resin, solvent pigment and additives.
### Table 1: Formations for the Production of 1 Litre of Polyester Paint

<table>
<thead>
<tr>
<th>Material</th>
<th>Trade name</th>
<th>Function</th>
<th>Specific gravity</th>
<th>Structural formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea formaldehyde resin</td>
<td>Uformite f-210</td>
<td>Curing agent/hardener</td>
<td>1.01</td>
<td>II II HOCH₂ NHCH HCH₂ NHCN HCH₂ OH</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>Leguval E60</td>
<td>Binder</td>
<td></td>
<td>∑ COCH CHCOOCH₂ CH₂ OCH₂ CH₂</td>
</tr>
<tr>
<td>Meth1ethyl ketone.</td>
<td>-</td>
<td>Solvent</td>
<td>0.7997</td>
<td>II CH₃ – C- CH₂ CH₃</td>
</tr>
<tr>
<td>Silicone solution soyadecthin no amide</td>
<td>- soyadecthin based</td>
<td>Anti-flooding wetting agent</td>
<td>1.01</td>
<td>0 nill II RC – N (CH₂ CH₂ OH)₃</td>
</tr>
<tr>
<td>Byk 031</td>
<td>-</td>
<td>Anti-flooding or defomer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td></td>
<td>Pigment</td>
<td>Nill</td>
<td></td>
</tr>
<tr>
<td>Alpha phthacynaice blue</td>
<td>-</td>
<td>Pigment</td>
<td>Nill</td>
<td></td>
</tr>
</tbody>
</table>
Table 2: *Raw materials and quantity used in grams*

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Quantity used in (gram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl ethyl ketone</td>
<td>200</td>
</tr>
<tr>
<td>Alphaptha cyanine blue</td>
<td>300</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>300</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>450</td>
</tr>
<tr>
<td>Soya-lecithin-based</td>
<td>80</td>
</tr>
<tr>
<td>By 031</td>
<td>300</td>
</tr>
<tr>
<td>Silicone solution</td>
<td>260</td>
</tr>
<tr>
<td>Urea formaldehyde</td>
<td>varying proportion (for the different samples) [100, 150, 200, 250, 300]</td>
</tr>
</tbody>
</table>

2.1 *Apparatus use for the production process*

Includes the following:
Weighting balance, Beaker, Mixer, High speed disperser (SWFS-300,) Otoper Hegman gauges (170mm x 65mm x 15mm)- DIN EN 1524

2.2 *Paint Manufacturing Process*

Pigment together with sufficient binder and solvent to make a free — flowing mix; mix is loaded into the mill until it is approximately two —third. The mill is then closed and fixed into a device whereby it rotates about its major axis, normally for a period of 30 minutes and 6hours, depending on the sizes and quantity of the material. This period allow for proper dispersion of the pigment. The mill based is emptied out and blended with the other ingredient that is mainly additives.

2.2.1 STAGE I

The solvent, resin and additives were divided into three parts because they are being added little by little. The measured quantity of pigment where added to the first part of the solvent resin and additives from proper grinding using a high speed disperser, which has a property to agitate for 40minutes to ensure homogenous dispersion of the particle in the medium, meanwhile, when this grinding was taking place glass, beads where added to the mixture to increase the shear forces and to regulate the temperature inside the beaker. The fineness of the paint was checked there after the pigment and the resin were dispersed in the solvent and additives. This stage is often called grinding.

2.2.2 STAGE II

This stage usually carried out by the second part of resin and solvent, and was agitated for a minimum of 20minutes. After proper agitation, the paint was served off in order to remove the glass bleeds and small particles inside the beaker. This stage is called let-down.
2.2.3 STAGE III

This stage is called made up because of the addition; resin solvent and currying/setting agent were added for another agitation. The essence of curing agent is to impart excellent colour and colour retention, hardness and chemical resistance. It was done for a minimum of 30 minutes, one litre of solvent blue was produced.

2.3. FLEXIBILITY TEST

This test describes the resistance to blending and the effect on adhesion and cracking to coating film. The equipment used for this purpose is the flatbed 600mm wide folding machine with a sharp—nosed mandrel around which samples are bent. The test is of two types the O—T and I-T bends.

2.3.1 O-T BEND METHOD

The sample is formed in the folding machine to an angle of approximately 45°c and is re-inserted into the folder. The sample is then flattened to 180°c blends. After blending, the formed edge is examined for cracking metal fracture and adhesion of coating film. The coating adhesion is assessed by a 1” cello tape pull-off, the cello tape is applied at 90°c to the axis of the bald rubbed down firmly and then pulled off with a raid and continuous action, the amount of paint stick is recorded as the percentage of the area blend.

2.3.2 I – T BEND METHOD

The sample panel used for o – T blend is further subjected to the same procedures – this is usually called double folding and the performance checked used the same method.

![Graph showing the influence of quantity of Urea-formaldehyde on paint flexibility and drying time.]

*Figure 1: Influence of quantity of Urea formaldehyde on paint flexibility and drying time*
Discussion of result

The degrees of flexibility was decreasing as the quantity of urea-formaldehyde was increasing from 100 —150 gram per litre of paint, the sample passed flexibility test further increased from 200 — 300 gram per litre of paint, failed flexibility test.

It was also observed that drying time was decreasing as the quantity of urea — formaldehyde was increasing, the formulation containing 100 — 150 gram per litre that passed flexibility test did so with a slow drying time of 120 and 98 minutes respectively, while the other formulation that failed flexibility test had good drying property.

We had a scheme in which drying time was decreasing as flexibility increased; we could not obtain an optimum formulation, both were virtually having the same effect on the paint. Comparing this to the commercially available polyester paint manufactured from imported raw materials, they usually had good flexibility at a drying time of about 30 minutes.

3.1 Cost of Paint Production

In an effect to produce polyester paint from suitable substitutes for some of the raw materials that will be cheaper and more readily available, a lot of expenses were incurred. Although in this research, the main cumin was to produce polyester from readily available materials, the cost of production was neglected in as much as the costing done here might not be taken to the actual cost of production if the paint was produced. Yet it gave an insight to the estimation of cost of production in the laboratory.

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Function</th>
<th>Local sources</th>
<th>Quantity use (Grams)</th>
<th>Cost (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl ethyl ketone</td>
<td>Solvent</td>
<td>TEMO chemical No 240 faulks roads Aba.</td>
<td>200</td>
<td>64.50</td>
</tr>
<tr>
<td>Alpha phthacynanine blue</td>
<td>Pigment</td>
<td>-</td>
<td>300</td>
<td>195.00</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>Pigment</td>
<td>-</td>
<td>300</td>
<td>110.00</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>Binder</td>
<td>-</td>
<td>500</td>
<td>250.00</td>
</tr>
<tr>
<td>Soya lecithin</td>
<td>Wetting agent</td>
<td>-</td>
<td>80</td>
<td>110.00</td>
</tr>
<tr>
<td>Byk 031</td>
<td>Anti form</td>
<td>-</td>
<td>220</td>
<td>70.00</td>
</tr>
<tr>
<td>Silicone solution</td>
<td>Anti flooding</td>
<td>-</td>
<td>260</td>
<td>145.00</td>
</tr>
<tr>
<td>Urea formadeyle</td>
<td>Curring agent</td>
<td>-</td>
<td>100 150 200 250 300</td>
<td>54 64 74 84 94</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total (N)</td>
</tr>
</tbody>
</table>

CONCLUSION

In this study it was not possible to obtain an optimum formulation using local raw material. The paint produced passed O-T and I-T (flexibility) test but it was characterized by a slow dry time of about 120 minutes.

This could have occurred as a result of the incompatibility of the polyester/urea — formaldehyde blend with the solvent (methyl ethyl ketone) used in this study. Because in some cases, solvent help in the fastening of curing and drying time.

The achieved result from the study can serve as a guide to paint formulator that are using locally available raw material. The application and use of the polyester paint should determine to increase the quantity of the setting agent or reduce it.

Proper study and research should be carried out on the raw material that could be used for a particular polyester paint formulation. This is to determine the compatibility of the different raw material. The inability to achieve an optimum formulation was due to the compatibility of the solvent with the binder blends.
When testing for flexibility solvent, physical condition of the laboratory such as temperature, relative humidity and strain rate of the environment should be controlled. The temperature of the laboratory and specimen should not be above room temperature 25°C while relative humidity 50 percent.

REFERENCES

R. Gras and H. Riemer, U.S. Patent 4,528,355 (1985); Hüls
Malcolm P. Stevens “Polymer Structure and Properties” pp.50—162