Biosciences, Biotechnology Research Asia Vol. **7**(1), 115-120 (2010)

Development of household surface coatings using some high tinctorial natural dyes

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(Received: January 08, 2010; Accepted: February 18, 2010)

ABSTRACT

Pigments from six Nigerian floras namely *Morinda lucida*, *Bixa orellana*, *Sorghum caudataum*, *Pterocarpus erinaceous*, *Tectona grandis and Zingiber officinale* were successfully isolated and compounded through formulation into household surface coatings as emulsion paints, gloss paints and lacquers using a paint industry's procedure. The formulated surface coatings with the natural dyes compared favorably well with the standards in terms of having high opacity on Morest chart, viscosity and high fastness properties of above 4.0 on a Gray scale of 5.0 as interior coatings. The lacquers proved highly effective and acceptable as wood finishes.

Key words: Coatings, emulsion, gloss, lacquer, natural dyes, paints.

INTRODUCTION

Surface coating is a material in liquid or powder form that when applied to a substrate forms a film possessing protective, decorative and or other specific properties[1]. The extent to which the use of coatings, colourants and paints can be utilized is an index of progress toward modern cilivilization. Organic coatings are based on a vehicle, usually an oil or resin, which after being spread out in a relatively thin film changes to solid. This change called drying may be entirely due to evaporation of a volatile solvent or by a chemical reaction, such as oxidation or polymerization[1].

Surface coatings could be paints, vanishes and lacquers. Paint is a liquid composition of a pigment suspended in a vehicle which after application in its liquid form to a substrate, changes or hardens and dries to form a solid opaque film[2]. Paints applied to materials changes the surface properties of the material such as gloss, colour, resistance to wear and chemical attack or permeability, without changing the bulk properties[3]. Vanishes are clear, unpigmented coatings, made by dissolving a resin (or the reaction product of a resin and a drying oil), in a suitable solvent. Lacquers are coatings for which the vehicle is a cellulose derivative. It dries by the evaporation of the solvent or thinner and forms a protective film from its non volatile contents. Lacquers are characterized by its rapid drying and distinctive odour [4]. Surface coating quality is judged by the length of time during which the material maintains its decorative and protective value. Different types of coating provide different application and resistance of properties, depending on the kinds and levels of ingredients used to formulate the coating. Some of the application and appearance properties of coatings include: colour, opacity, flow and leveling, sheen gloss level, spattering and foaming tendencies and also adhesion among others. In general terms, all coatings have five basic components which impact these properties mentioned above. These components are: pigments, binder (film-former), solvents/ thinner, extenders and additives. The roles of this individual component in surface coatings, as well as the production and application techniques of surface coatings are found in literatures [5-7]. Coatings could be classified in various ways according to: end use (decorative, auto, industrial and marine); solvent used (water based / solvent

based) and higher performance or special type coatings. This study had been prompted by the reported high tinctorial strength for the natural dyes used in the formulation, namely: *Bixa orellana, Morinda lucida, Pterocarpus erinaceous, Sorghum caudatum, Tectona grandis and Zingiber officinale* [8, 9]. It has as its main objective, the use of these natural dyes as main pigments in the formulation of surface coatings, particularly, emulsion and gloss paints, and lacquers, for household utilization. The performance properties of the resulted formulated surface coatings are then studied and compared with the surface coatings prepared with synthetic dye (Procion yellow), organic and inorganic pigments (red iron oxides) as standards.

MATERIAL AND METHODS

Sources of materials and preparations

Natural dyes from the following plants: *Bixa orellana and its resins, Morinda Lucida, Pterocarpus erinaceous, Sorghum caudatum, Tectona grandis and Zingiber officinale* were collected from the Industrial Chemistry Department, Federal University of Technology, Akure, Nigeria. Procion yellow R dye and other surface coating formulation materials were obtained from Nigerian Textile mills PLC and Niger Cedar Industries Limited, Ikeja, Nigeria respectively. The above named natural pigments in conjunction with other surface coating materials as obtained from the Industry were formulated into

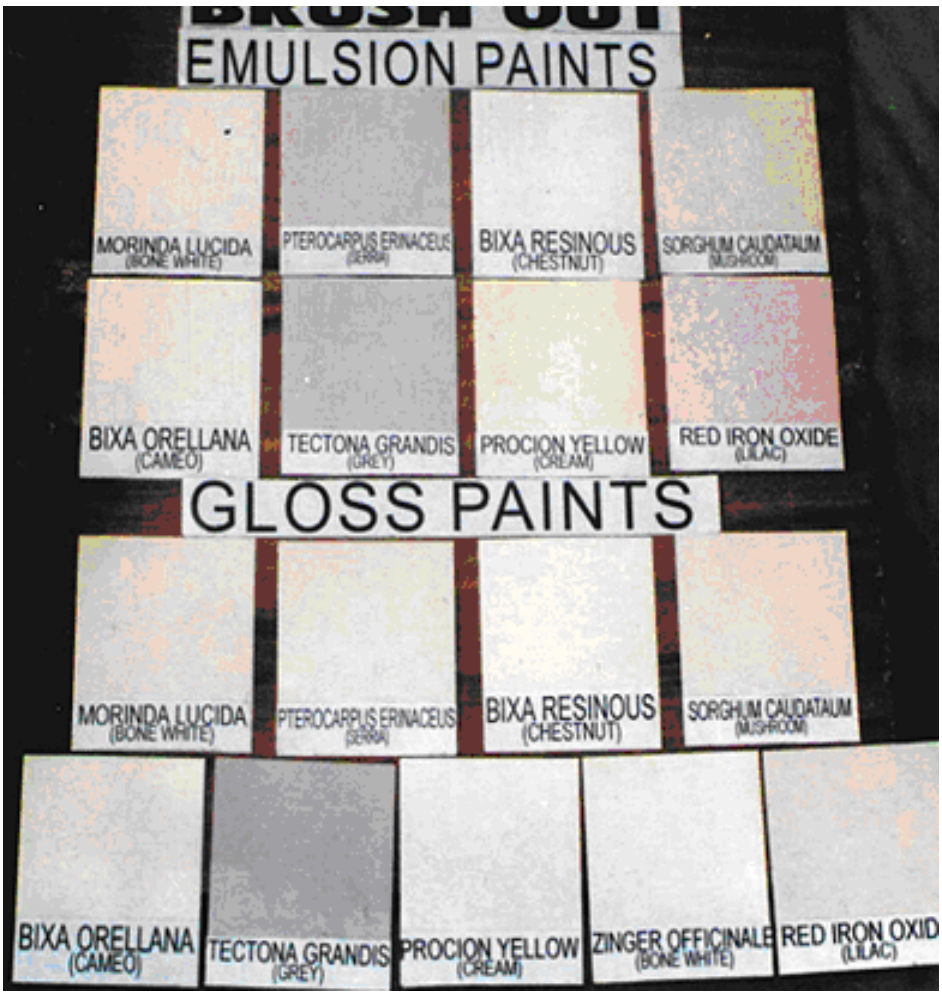
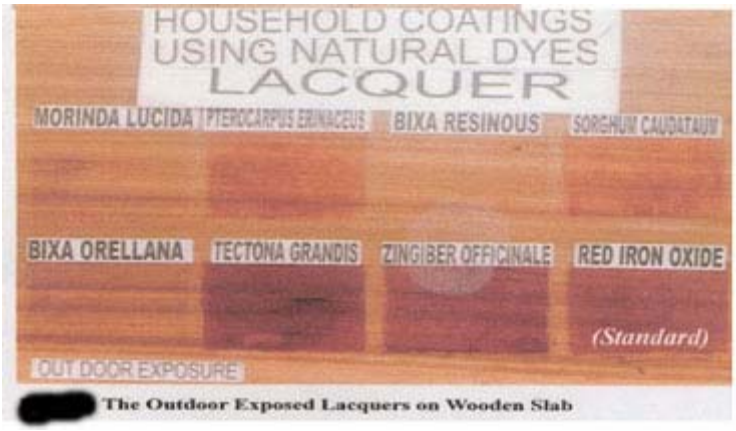


Fig. 1: The brush out (Application of emulsion and gloss pains cards)

Fig. 2: Application of the surface contings on wooden and concrete slabs



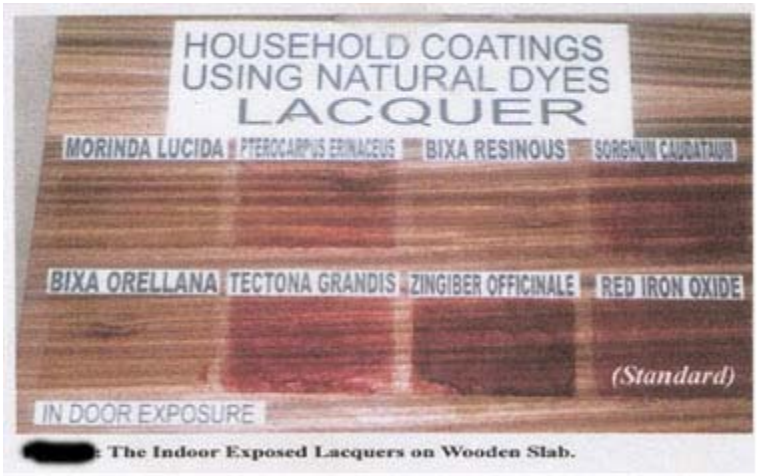


Fig. 3: Applications of lacquers on wooden slabs

gloss, emulsion and Lacquers according to the procedure of Niger Cedal Indusries limited, Nigeria. Prior to the formulations, the natural dyes were pre-dissolved in a little alkaline solution (5 ml). Various assessment tests as oil absorption, viscosity, opacity, drying time among others, were carried out on the products using Nigeria Industrial standard [10](NIS) methods.

RESULTS AND DISCUSSION

The results obtained from the assessment tests were shown in Tables 1-5. Table 1 show the colour of the finished surface coatings products. The textures of most of the natural dyes which were not smooth were improved through grinding to increase their surface area as well as their oil absorption properties. The oil absorption properties of the natural dyes compared to the standard were high and this reduces their rate of dispersion in the vehicle (water/kerosene) and hence, required excessive mixing (Table 2). Other physical parameters tested compared favorably well with the standard (Table 3). Viscosity is defined as the resistance to flow of a liquid paint. All the coatings, include the standards has good viscosity and these facilitates their ease of application and spreading rate. The coatings so formulated showed a

Table 1: The final colour imparted by the dye/pigment samples in the finished surface coating Products

Dye/pigment samples	Emulsion paints*	Gloss paints*	Lacquers
Morinda Lucida	Bone white	Bone white	Gold
Pterocarpus erinaceous	Serria	Serria	Grey
Bixa resionous	Chestnut	Chestnut	Golden orange
Sorghum caudataum	Mushroom	Mushroom	Dark red
Tectona grandis	Grey	Grey	Wine
Zingiber officinale	-	Bone white	Golden brown
Procion yellow (synthetic) (STD)	Cream	Cream	-
Organic red iron oxide (STD)	-	-	Brown
Inorganic red iron oxide (STD)	Lilac	Lilac	

*The colour in accordance with Niger Cedar Industries Colour Chart.
STD = Standard pigment/dye

Table 2: The physico-chemical parameter of the pigments/dye

Dye/Pigment Samples	Colour	Texture	Weight of oil absorbed (gram)	pH values (emulsion paint)
Morinda lucida	Golden brown	Crumble	19.40	8.61
Pterocarpus erinaceous	Black	Coarse	14.90	8.70
Bixa resinous	Golden red	Crumble	13.40	8.80
Sorghum caudataum	Black	Coarse	10.00	8.73
Bixa orellana	Red	Coarse	6.00	8.98
Tectona grandis	Black	Coarse	10.20	8.90
Zingiber officinale	Bright red	Coarse	9.00	-
Procion yellow (synthetic) (STD)	Deep red	Smooth	4.00	7.80
Organic red iron oxide(STD)	Red	Smooth	3.40	-
Inorganic red iron oxide(STD)	Red	Smooth	3.60	7.50

Table 3: The Viscosity values of finished surface coating products

Dye/pigment samples	Viscosity		
	Emulsion (Pascal sec)	Gloss (secs)	Lacquer (secs)
Morinda lucida	11.00	110.0	26.0
Pterocarpus erinaceous	11.00	111.0	27.0
Bixa resinous	11.10	110.0	25.0
Sorghum caudataum	10.90	114.0	26.0
Bixa orellana	11.00	113.0	25.0
Tectona grandis	11.00	112.0	27.0
Zingiber officinale	-	116.0	28.0
Procion yellow (synthetic) (STD)	10.80	110.0	26.0
Organic red iron oxide(STD)	-	-	26.0
Inorganic red iron oxide(STD)	11.00	110.0	

Table 4: The water resistance test results on the finished surface coating Products

Dye/Pigment Samples	Water resistance		
	Emulsion paints	Gloss paints	Lacquers
Morinda lucida	+	+	+
Pterocarpus erinaceous	-	+	+
Bixa resinous	+	+	+
Sorghum caudataum	-	+	+
Bixa orellana	+	+	+
Tectona grandis	-	+	+
Zingiber officinale	-	+	+
Procion yellow (synthetic) (STD)	-	-	+
Organic red iron oxide(STD)	-	+	+
Inorganic red iron oxide(STD)	-	+	+

Key: + = High resistance, no colour change = Low resistance, slight colour change

Table 5: The Mean Light Fastness Results of the Finished Paint Products after 5 weeks of exposure

Dye/pigment samples	Emulsion		Gloss		Lacquer	
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
Morinda lucida	4.40	3.60	4.60	3.80	4.80	4.40
Pterocarpus erinaceous	4.40	2.80	3.60	2.80	4.40	4.00
Bixa resinous	4.40	3.80	4.20	3.80	4.40	3.80
Sorghum caudataum	3.20	2.40	3.80	3.00	4.40	3.80
Bixa orellana	4.20	3.60	4.40	3.80	4.40	3.80
Tectona grandis	3.80	2.60	4.40	3.20	4.80	4.20
Zingiber officinale	-	-	3.60	2.80	4.20	3.80
Procion yellow (synthetic) (STD)	4.40	2.40	3.80	2.80	-	-
Organic red iron oxide (STD)	-	-	-	-	5.0	5.0
Inorganic red iron oxide (STD)	5.0	5.0	5.0	5.0		

Key: Grey scale rating: 1-2 Poor Light Fastness 3 -4Good Light Fastness >5 Very good Light Fastness

considerable good obliterating power (opacity) on Morest chart and this was manifested on the applied substrates- concrete and wooden slabs (Fig.1 and Fig.2). The emulsion paints prepared with Morinda and the Bixas showed high resistance to water while others including the standards vary slightly in hues. However, all their corresponding gloss (except Procion yellow) and lacquers exhibited high resistance to water (Table IV). There were no considerable changes in the overall properties of the coatings. They showed good adhesions, indicating that the surface coatings were adequately formulated and the binder used (Polyvinyl acetate) has good binding strength [11].

The formulated surface coatings from natural dyes showed relatively brighter colours, particularly those made using the pigments of Morinda, Tectona, Pterocarpus and Zingiber (fig. 1). In lacquers, Zingiber and Bixa manifested a golden brown and transparent orange colour respectively when cured. These are desirable hue, attractive and effective as wood finishes on household furniture when applied (Fig.3). Generally, all the surface coatings include the standard, exhibited low fading resistance to light in outdoor exposures (Table V). This is due to the fugitive nature of the pigments. Their hues changes after exposure to light energy for five weeks.

CONCLUSION

The natural dyes used in this study showed good tinting strength (hiding power), water resistance and high compatibility with other ingredients of surface coatings' formulation. Nevertheless, they are not strong towards high radiation energy and these would restrict their uses as exterior surface coatings. However, for ingenuity and originality, they would serve well as paints on concrete walls or lacquers on wood finishes for interior decorative purposes.

ACKNOWLEDGMENTS

The authors are grateful to the Nigerian Textile mills PLC, for supplying the Procion yellow dye and Niger Cedar Industries Limited, Ikeja, Lagos, Nigeria, for providing the other surface coating materials and for the use of some of their machines respectively.

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