THE DEVELOPMENT OF EPOXIDISED PALM OIL ACRYLATE (EPOLA) AND ITS APPLICATIONS

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INTRODUCTION

In recent years, there are growing trends in using vegetable oils as raw materials in resin production. The reasons towards moving into this direction are; stricter environmental legislation towards maximum allowable volatile organic contents (VOC), preserving the earth's natural resources and less accumulation problems in the environment.

Vegetable oils (e.g. soybean, linseed, tung, sunflower, corn, palm, cotton etc.) are chemically known as glycerol triesters of polyunsaturated fatty acids or unsaturated triglyceride oils. They are products of domestic agriculture and are, hence, renewable. Their supply is plentiful and therefore, they are inexpensive. These oils are quite different from each other. They are categorised into three groups : drying oils, semi-drying oils and non-drying oils ; or by their power to absorb oxygen from surrounding air, which is directly proportional to the iodine value of the oil which measure the extent of unsaturation of the fatty acids present. The fatty acids are characterised as saturated or unsaturated. The more unsaturated the oil, the faster it will react with oxygen and polymerise.

Table 1 : Typical structures of Unsaturated Triglyceride Oils

Name	Structure
Soybean oil	$CH_3-(CH_2)_4-CH=CH-CH_2-CH=CH-(CH_2)_7-CO_2-CH_2$ $CH_3-(CH_2)_4-CH=CH-CH_2-CH=CH-CH_2-CH=CH-(CH_2)_4-CO_2-CH$ $CH_3-(CH_2)_7-CH=CH-(CH_2)_7-CO_2-CH_2$
Palm oil	$CH_3-(CH_2)_7-CH=CH-(CH_2)_7-CO_2-CH_2$ $CH_3-(CH_2)_4-CH=CH-CH_2-CH=CH-(CH_2)_7-CO_2-CH$ $CH_3-(CH_2)_{13}-CO_2-CH_2$

Tung and linseed (nine unsaturation) oils have been formulated into lithographic varnishes for a long time because they dried fast and hard. Linseed and soybean (six unsaturation) oils are widely used in alkyd resins, which are used in dispersion and flushing vehicles. Soybean oil which is well known for its colour retention and low odour properties, has also been widely used in napkin and metal decorating inks (Chris Halvorsen, 1992).

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Table 2 : Fatty Acids composition (%) of vegetable oils.

Name	linseed	soybean	palm	number of carbons	number of double bonds
Oleic	17	24	43	18	1
Linoleic	14	51	11	18	2
Linolenic	60	9	0.4	18	3
Palmitic	6	12	40	16	0
Stearic	5	4	4.4	18	0

Table 3 : Prices of selected oils and fats, 1987-1990 (U.S.$/ton).

Product	1987	. 1988	5/89	7/90
Soybean oil, Dutch, fob ex-mill	334	463	460	434
Coconut oil, Phil/Indo. cif Rotterdam	442	565	589	330
Palm kernel oil, Malaysia, cif Rotterdam	426	539	528	335
Tallow, U.S bleach-fancy, cif Rotterdam	356	412	369	345

Source : Oil World.

World **palm oil** (*Elaeis guineensis)* production grew from 1.7 million metric ton in 1970 to 10 million metric ton in 1990 for an average annual increase of 9.3%. Malaysia provides 57% of the world's production. Malaysia's role as an exporter is even greater, accounting for 75% of world exports. Indonesia, Papua New Guinea, and the Ivory Coast account for an additional 20% of the world production and export (Kaufman *et. al.*, 1990).

Table 4 : Average annual yields of selected vegetable oils.

Oil	Annual yield (Kg/hectare)
Palm oil	4000-5000
Palm kernel oil	400-500
Coconut oil	710
Soybean oil	389
Peanut oil	875

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Table 5 : World production of selected oils and fats as raw materials for oleochemicals (million ton)

Oils & fats	1950	1960	1970	1980	1989	1990f	1995f	2000f
Soybean	2.1	4.0	6.1	12.2	15.0	16.1	18.2	21.0
Tallow	2.2	3.6	4.4	6.0	6.6	6.6	7.1	7.0
Coconut	1.9	2.1	2.2	3.3	2.8	3.1	3.8	4.2
Palm	0.9	1.1	1.7	5.0	10.3	10.8	17.8	22.0
Palm kernel	0.4	0.4	0.4	0.7	1.3	1.4	2.3	2.8
Others	16.1	20.9	25.3	29.6	41.3	41.2	35.2	50.0
Total	23.6	32.1	40.1	56.8	77.3	79.2	84.4	107.0

f : forecast.
Source : 1950 to 1995f - Oil World.
2000f - Estimated.

PRODUCTION OF RADIATION CURABLE RESIN AND ITS APPLICATIONS

Palm oil and its products (palm olein and stearin) contain level of unsaturation that are half or less than half of that of soybean oil. It has therefore never been thought of as suitable raw materials for the production of resins. However it was of interest to find out to what extent could palm oil or its products compare with linseed oil, soybean oil etc. As even a slight substitution is a step towards changing the situation from having to import to being self-sufficient.

For the last three years, one of the main research activities in radiation processing laboratory, UTN, has been in modifying materials from indigenous natural sources particularly palm oil products into radiation curable oligomers/resins, namely **acrylated oils**. Epoxidation of palm oil products has been reported to yield materials namely epoxidised palm oil products (EPOP) suitable as plasticiser and stabiliser for plastics (Salmiah *et. al.*, 1987). Acrylated palm oil is prepared through **acrylation process**, whereby, acrylic acid is introduced into **oxirane** group of the EPOP, the process is similar to those used to epoxy acrylate manufacture (Hussin *et. al.*, 1990). The acrylated products called epoxidised palm oil products acrylate, **EPOLA**, was found curable when subjected to ultraviolet (UV) light giving soft coatings. Addition of crosslinkers such as difunctional and trifunctional acrylates enhanced the physical properties of coatings. Polyurethane acrylate (PUA) can also be added into formulation to improve properties particularly flexibility and toughness (Mohd. Hilmi *et. al.*, 1991). Acrylated oils are having advantages of excellent pigment wetting, low cost, good adhesion and low skin irritancy, but of the disadvantages of slow cure and soft film (for surface coatings). Later it was discovered that EPOLA based formulations (with the incorporation of other oligomers and monomers) could satisfactorily be coated on wood substrates (rubberwood parquets) without any major defects. Their properties were almost comparable with commercial resins and possess a great potential to be used for radiation curable finishes (Mohd. Hilmi *et. al.*, 1992).

The use of acrylated epoxidised palm oil products (EPOLA) for other applications such as radiation curable filler/sealer and radiation curable pressure sensitive adhesives has also been ventured. Early results showed that EPOLA is also promising to be used in both applications.

References.

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