Novel polymeric materials from palm oil derivatives

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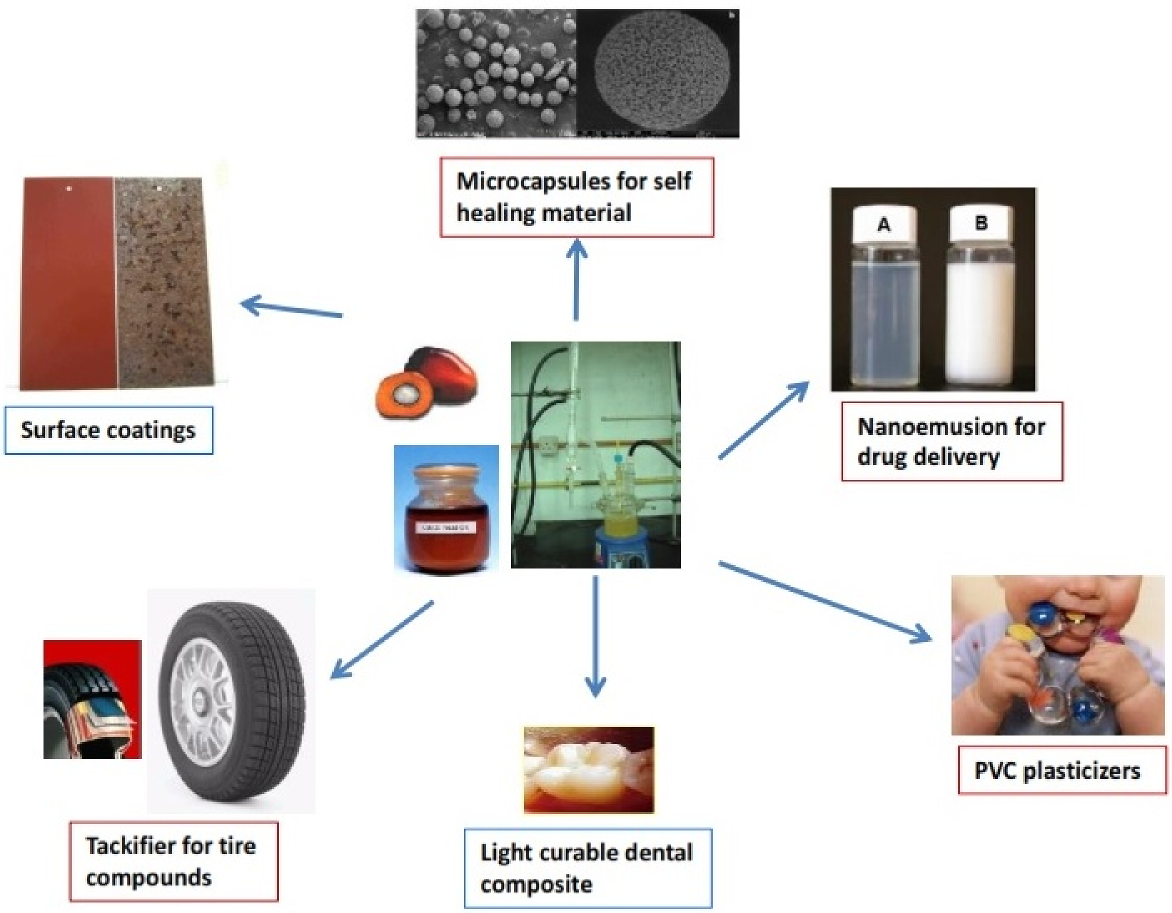

Figure 1: Novel palm oil-based polymers for different applications

Palm oil is not a polymer; but through chemical reactions it can be converted to intermediates with different functional groups that could interact with other monomers, either through condensation reactions or free radical additions or a combination of both mechanisms to form novel materials with interesting properties and applications.

Many research studies have reported the synthesis of alkyds from vegetable oils for surface coatings. In particular, soybean, castor, linseed and tall oils are very suitable because these oils have very high level of unsaturation which enable them to air-dry through oxidation. Palm oil is non-drying oil because of its low iodine value and its alkyds are not capable of forming film by air oxidation. This could be overcome by adopting alternative crosslinking reactions not requiring unsaturation. Water soluble alkyds are made with 28-45% w/w of palm stearin by two stages. The palm stearin was first reacted with glycerol to form monoglycerides, which then polymerize with phthalic anhydride and pentaerythritol to form polyester with excess hydroxyl groups. Trimellitic anhydride was then added to graft the hydrophilic carboxylic acid groups into the polymer structure. The alkyd was neutralized with triethylamine and solubilized in water with butanol and butylcellosolve as cosolvents. The alkyds have been formulated into water-based clear baking enamels by mixing with commercial methylated melamine formaldehyde resin. Color enamel paints were also produced through incorporating pigments and other additives. These enamels can be cured at temperature between 100-140°C and they exhibit good adhesion, film hardness and high gloss, and the resulted palm oil-based polymers have numerous applications.

A tire is an assembly of numerous components that are built up on a drum and then vulcanized in a press under heat and pressure. Few layers of the tire components need to be held in place by a tacky compound. In a collaborative research project with Sumitomo Rubber, sticky palm oil-based alkyds were developed as tackifiers in tire compounds. These tacky alkyds have performed better than the conventional tackifier such as polyterpene and petroleum resin. In addition, the tackifier was absorbed into the rubber during vulcanization and has modified the properties of the track and the side-wall rubber, improving the tire performance in terms of better road gripping and lower rolling resistance.

Amalgam is one of the oldest dental materials which has been used for filling of tooth cavities. It can release minute amounts of mercury whose toxicity at high intake levels is well-established. People with amalgam filling were found to have higher concentrations of mercury in their blood, urine, kidney and brain. Consequently, mercury amalgam has become less popular due to its poor aesthetic value and worry about mercury poisoning. The use of amalgam has been banned many countries. Composite resins based on Bis-GMA (2,2-bis[4-(2-hydroxy-3-methacryloxyprop-1-oxy)phenyl]propane) and TEGDMA (triethylene glycol dimethacrylate) have been developed. These resins have two acrylate terminals that could be polymerized by free radical initiators activated by light. In collaboration with the staff of the Faculty of Dentistry, University of Malaya, new acrylate terminated oligomer based on a palm oil polyol has been developed as the matrix system for dental restorative composite materials. At the first stage a palm oil-based polyol with three hydroxyl groups was reacted with excess diisocyanate to produce a urethane pre-polymer with three terminal –NCO groups. Next, this pre-polymer is reacted with HEMA (hydroxylethylmethylacrylate) to produce the acrylate terminated BPUTMA (Biopolyol urethane triimethacrylate). Compared to the commercial composite resins, the BPUTMA can be cured with light faster and possesses better mechanical properties.

Polyvinyl chloride (PVC) is one of the important technical polymers that has been utilized in many industries. It can be found in wide varieties of products, ranging from structural materials and piping, medical devices, and household appliances. Raw PVC is a rigid plastic, in order to improve the flexibility, plasticisers are added during fabrication of products. These plasticisers are incorporated into PVC through weak physical interaction. Many case studies have shown migration of plasticisers out from PVC intravenous blood bags, PVC container, plastic kitchen wrap, and plastic toys. Consequently, many of these plasticisers (such as DOP) which are harmful to health have been banned from such applications. We have synthesized polyesters from palm oil derivatives to function as plasticisers. Besides being able to soften the hard plastic, they have improved the thermal stability of PVC and shown good migration resistance presumably through chain entanglement.

A nanoemulsion has particle size less than 100 nm, and appears "transparent". While is a normal emulsion (particle size >0.1 mm) appears opaque like latex. The low molecular weight alkyds synthesized from palm oil and natural occurring carboxylic acids and glycerol and emulsified in non-toxic surfactant, are of interest for the production of nanoemulsion as delivery systems for nucleic acids, proteins and small molecule drugs. These alkyds nanoemusion exhibit good biocompatiblity with no measurable cytotoxicity at concentrations of 3-100 µg/mL following exposure for 24, 48 and 72 hours. Phenytoin, a drug for wound healing, has been succeefully loaded in the nanoemulsion at 3-200µg/mL. Results show no drug-alkyd interactions over extended time period and absence of drug degradation on storage.

The failure of many structural polymers begins from cracks within the materials. Efforts are being made to integrate self-healing ability to the material. One of the ways to achieve this objective is to store "healing agents" in microcapsules that are then embedded into the polymer matrix. The healing process is triggered when the cracks rupture the microcapsules, releasing the healing agent that could flow to fill the gap and solidify through suitable reaction mechanism such as crosslinking with certain reactive groups of the matrix to repair the crack. Our recent works have shown that palm oil alkyds having free carboxylic acid groups can react with epoxidized natural rubber. This observation has led us to the idea of using the alkyd for self-healing application in epoxy matrix.

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