# Plant Oil-Based Polymer: Jatropha Curcas

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## INTRODUCTION

Plant oils are derived from many crops and basically classified into edible or non-edible oil groups (Figure 1). Plant oils are triglycerides and contain various fatty acids, which differ in chain length, composition, distribution, and location (Sun, 2013). They comprise saturated and unsaturated oil which result variation in physical and chemical properties. Resin matrices and adhesives can be derived from these triglycerides by applying similar approaches of producing petroleum-based resin and adhesives. This can be done by introducing polymerizable groups to many active sites of triglycerides, such as double bonds, allylic carbons, and ester groups (Sun, 2013).

**PLANT OIL RESOURCES**

| Edible oil | Non-edible oil |
|---|---|
| Oil Palm | Jatropha |
| Soy bean | Karanja |
| Corn | Hochst |
| Linseed | Castor |
| Rapeseed | Polanga |
| Sunflower seed | Tung |
| Coconut | Chinese tallow |
| Peanut | Rubberwood seed |
| Sesame | Tobbacco |
| Olive | Polanga |
| Almond | Sea mango |
| Cocoa butter | Soapnut |
| Walnut | Neem |

**Figure 1. General classification of plant oil and resources**
(Adapted from Atabani et al., 2013)

Generally, three main techniques that been used to produce resin from plant oil. First technique is to reduce the triglycerides into monoglycerides. Polymerizable groups, such as maleate half esters, can be attached to the monoglycerides, allowing them to polymerize through free-radical polymerization. The second technique is to functionalize the unsaturated sites and reduce the triglycerides to monoglycerides, which can form monomers by reacting with maleic anhydride, allowing polymerization by free-radical polymerization. The third technique is by attaching polymerizable chemical groups, such as maleinates and acrylic acid, or by converting the unsaturated sites to epoxies or hydroxyl functionalities, making the triglycerides capable of polymerizing via ring- opening, free-radical, or polycondensation reactions (Wool and Sun, 2005). The third technique is wide and commonly used due to much cost effective, practical and simple step than the other two techniques. Such reactions produce bio-based polymers that have properties and costs comparable to those of petrochemical-based adhesives and resins.

### *Jatropha Curcas*

In Malaysia, jatropha has been selected as one of national commodities after oil palm and rubber tree. The Malaysian Rubber Board is a government body that been appointed to look on development related to jatropha in Malaysia. Unlike oil palm, which is planted for oil and lignocellulose biomass and rubber tree for latex and timber, jatropha is planted mainly for biodiesel production. With suitable climatic conditions (i.e. temperature, rain fall), soil condition and adequate area for commercial plantation, it is possible to cultivate jatropha in most part of the country (Mofijur et al., 2012). Besides, jatropha can be cultivated on underutilize land of which is usually left abandoned due to not suitable for food crop cultivation. BATC Development Berhad has been actively engaged in jatropha plantation and bio-fuel industry since 2007 in Malaysia. About 600,000 acres planted areas, 3.3 million areas land-banks and more than 300 nurseries and collection centres were reported in Malaysia (Bionas, 2011). In worldwide, according to International Jatropha Organization, around 330,000 km2 of land cultivated with jatropha producing 160 metric tonnes of seed and 95% of its total production will be cultivated in Asia by year 2017 (Taib, 2017).

Jatropha curcas or locally known as "Jarak Pagar" is a shrub tree with height of 5 to 7 m tall under family of Euphorbiaceous, which is widely grown in South America, South-West Asia, India and Africa (Mofijur et al., 2012). The fruits of jatropha can be harvested after 3 to 5 years of planting and the life expectancy is 50 years.

The fruit is a kernel which contains three seeds each and can produce about 2 to 4 kg/seed/tree/year for plant that planted in good conditon soil, whilst about 1 kg/seed/tree/year in poor soil (Saalah et al, 2015). Figure 2.8 shows jatropha trees, fruits, seeds and oil. It has been reported that Jatropha curcas produces about 2000 litres of oil in one hectare annually (Akbar et al., 2009). Jatropha oil, contains about 79% of unsaturated fatty acid mainly oleic acid (43.1%) and linoleic acid (34.1%) (Sarin et al., 2007).

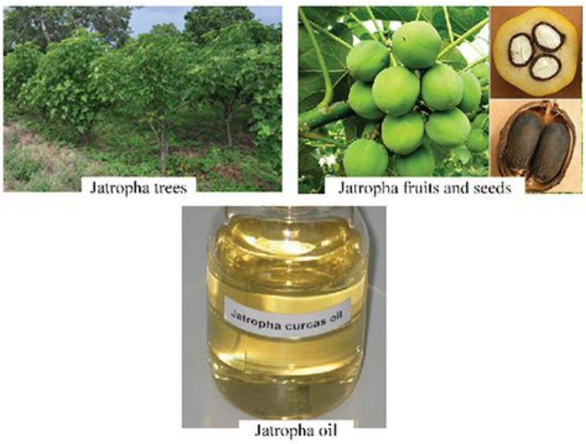


**Figure 2. Jatropha trees, fruits, seeds and oil**

Jatropha oil was classified as non-edible due to phorbol ester contain, which is toxic for human consumption (Kumar and Sharma, 2008). The oil content of jatropha seed was reported at 63.13 %, which is higher than palm kernel, linseed and soybean with oil content value of 44.6 %, 33.3 % and 18.4 %, respectively (Akbar et al., 2009). The yield, however, highly depends on the extraction method as well as the feedstock quality. Jatropha oil can be used to fabricate adhesive and coatings with promising properties in the polymer industries (Aung et al., 2014). Table 1 shows the compositions of fatty acids contains in jatropha oil compared with selected major plant-based oil.

| Fatty acids | Jatropha oil | Palm oil | Sunflower oil | Soy bean oil |
|---|---|---|---|---|
| Oleic 18:1 | 44.7 | 39.2 | 21.1 | 23.4 |
| Linoleic 18:2 | 32.8 | 10.1 | 66.2 | 53.2 |
| Palmitic 16:0 | 14.2 | 44.0 | - | 11 |
| Stearic 18:0 | 7.0 | 4.5 | 4.5 | 4.0 |
| Palmitoleic 16:1 | 0.7 | - | - | - |
| Linolenic 18:3 | 0.2 | 0.4 | - | 7.8 |
| Arachidic 20:0 | 0.2 | - | 0.3 | - |
| Margaric 17:0 | 0.1 | - | - | - |
| Myristic 17:0 | 0.1 | 1.1 | - | 0.1 |
| Caproic 6:0 | - | - | - | - |
| Caprylic 8:0 | - | - | - | - |
| Lauric 12:0 | - | 0.2 | - | - |
| Capric 10:0 | - | - | - | - |
| Saturated | 21.6 | 49.9 | 11.3 | 15.1 |
| Mono unsaturated | 45.4 | 39.2 | 21.1 | 23.4 |
| Poly unsaturated | 33.0 | 10.5 | 66.2 | 61.0 |

Source: Saalah, 2015

The structure of triglycerides in plant oil itself varies from molecule to molecule. For instance, Salimon and Ahmed (2012) reported that jatropha oil contains more than 11 different structures of triglyceride, mainly OLL (22.54 %), PLL (25.41 %), OOL (23.06 %), OOO (8.02 %), POL+SLL (8.19 %), LLL (5.02 %), POP (2.14 %), and PPP (2.90 %), (L stands for linoleic, O for oleic, and P and S for palmitic and stearic acids). Figure 3 shows a general jatropha oil structure consisting of a glycerol backbone attached to oleic, linolenic and stearic acids.

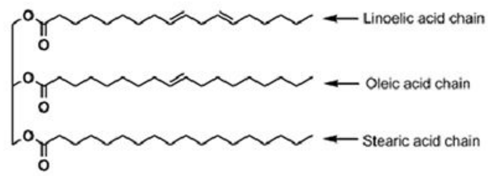


**Figure 3. General structure of tryglyceride of jatropha oil**
(Source: Saravari and Praditvatanakit, 2013)

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