CHAPTER 2

CHEMISTRY OF CASTOR OIL

Castor oil is derived from the bean of the castor plant, Ricinus communis L., of the family Euphorbiaceae. The castor plant occurs in practically all tropical and subtropical countries, either wild or cultivated. Castor oil is also known as Ricinus oil, oil of Palma Christi, tangantangan oil and Neoloid.

Typical of most fats, the oil is a triglyceride of fatty acids. What is unique is that the fat contains 87-90 % ricinoleic acid which is a fatty acid with 18 carbon atoms, one double bond in the ninth and tenth positions and one hydroxy group adjacent to the twelth carbon atom. It is also a 12-hydroxy oleic acid which structure is shown in Figure 2.1

2.1 Fatty acids composition of castor oil

The composition of fatty acids in castor oil derived from analysis of the methyl ester of castor oil fatty acid with gas chromatographic methods is given in table 2.1 (2) below :

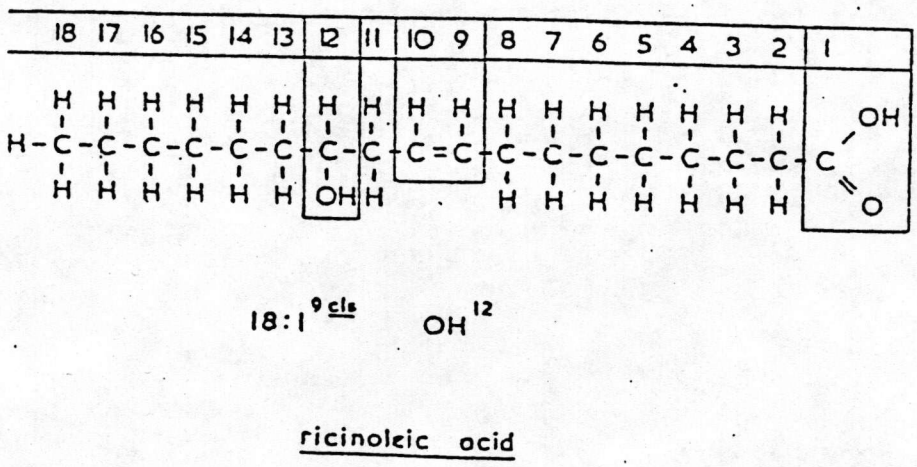
Table 2.1 Fatty Acids Composition of Castor Oil

Fatty Acid	Percentage
Palmitic acid	0.9 to 1.2
Stearic acid	0.7 to 1.2
Oleic acid	3.2 to 3.3
Linoleic acid	3.4 to 3.7
Linolenic acid	0.2
Ricinoleic acid	89.0 to 89.4
Dihydroxy stearic aicd	1.3 to 1.4

The structure of the glycerides of castor oil has been ascertained with approximately 68 % tri-ricinolein, 28 % di-ricinolein, 3 % mono-ricinolein and 1 % ricinoleic acid. These typical analytic values for castor oil may vary, according to the origin of the beans and on the analytic methods used.

2.2 Characteristics of Castor Oil

No other known natural oil contains a similarly high content of hydroxy fatty acid. This characteristic composition of glycerides distinguishes castor oil from all other vegetable oils and fats and is responsible for its remarkable physical and chemical properties. The non-drying castor oil has the highest viscosity (which changes only slightly at different temperatures) of all vegetable oils.



ricinoleic acid

Figure 2.1 Structure of ricinoleic acid

Castor oil also has the highest density of all oils. Unlike all other vegetable oils, it is miscible with alcohol in every concentration, best it has only limited miscibility with aliphatic petroleum solvents. Its remarkable cold resistance (the pour point is 16°C), equally remarkable heat resistance and ability to burn almost without residue give it the properties of a lubricant. Refined castor oil is an almost colorless, slightly yellowish oil with the following characteristics (2) :

Table 2.2 Characteristics of Castor Oil

Density (20°c)	0.955 to 0.968 g/ml
Refractive index n_D^{20}	1.476 to 1.479
Saponification Value	175 to 187
Iodine Value	82 to 88
Unsaponifiable matter	0.3 to 0.7 %
Hydroxyl Value	Minimum 160
Viscosity (20°c)	9.5 to 11.0 poise
Miscibillity	Complete in alcohol and glacial acetic acid With hydrocarbons at normal temperatures in limited guantities, only

2.3 Chemical Reaction of Castor Oil

Because of the hydroxyl groups, double bonds, and ester linkages in castor oil provide reaction sites for the preparation

of many useful derivatives. Chemical reactions commercially used to create important castor oil derivatives are as follow ;

Acetylation

Alkoxylation

Amination

Caustic fusion

Chemical Dehydration

Epoxidation

Esterfication

Hydrogenation

Isocyanate Reaction

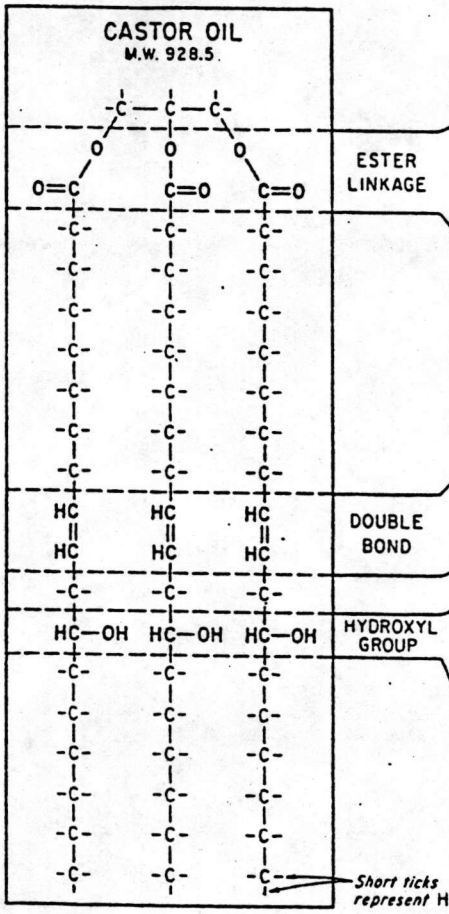
Oxidative Polymerization

Pyrolysis

Saponification

Sulfation

The diagram which shows the fundamental structure of castor oil and its functions in these reaction was shown in Figure 2.2



CHEMICAL REACTIONS OF CASTOR OIL

NATURE OF REACTION	ADDED REACTANTS	TYPE OF PRODUCTS
(1) Hydrolysis	Acid, enzyme, or Twitchell reagent catalyst	Fatty acids Glycerol
(2) Esterification	Monohydric alcohols	Esters
(3) Alcoholysis	Glycerol, glycols, pentaerythritol, etc.	Mono- and diglycerides, monoglycols, etc.
(4) Saponification	Alkalies Alkalies plus metallic salts	Soluble soaps Insoluble soaps
(5) Reduction	Na reduction	Alcohols
(6) Amidation	Alkyl amines, alkanolamines, etc.	Amine salts Amides
(7) Halogenation	$SOCl_2$	Fatty acid halogens
(8) Oxidative polymerization	Heat, air, oxygen	Polymerized oils
(9) Hydrogenation	Hydrogen (moderate pressure)	Hydroxystearates
(10) Epoxidation	Hydrogen peroxide	Epoxidized oils
(11) Halogenation	Cl_2, Br_2, I_2	Halogenated oils
(12) Addition reactions	S, maleic acid	Polymerized oils
(13) Sulfonation	H_2SO_4	Sulfonated oils
(14) Dehydration	Catalyst (plus heat)	Dehydrated castor oil
(15) Caustic fusion	NaOH	Sebacic acid Capryl alcohol
(16) Pyrolysis	High heat	Undecylenic acid Heptaldehyde
(17) Halogenation	PCl_5, $POCl_3$	Halogenated castor oil
(18) Alkoxylation	Ethylene and/or propylene oxides	Alkoxylated castor oils
(19) Esterification	Acetic-, maleic-, phthalic anhydrides	Alkyl castor oils
(20) Amination	Oxidation plus NH_3	12-amino oleate
(21) Sulfation	H_2SO_4	Sulfated castor oil (Turkey red oil)
(22) Urethane reactions	Tolylene diisocyanate	Polymers

Figure 2.2 Chemical reactions of castor oil