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FULL LENGTH ARTICLE

Aspects of the behavior of some pentaerythritol ester base synlubes for turbo-engines

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KEYWORDS

Polyol esters;
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Abstract In this work a series of pentaerythritol esters have been synthesized. Dean Stark apparatus has been used to measure the water separated periodically as one of the resultants giving an indication about reaction progress. Elementary analyses, mean average molecular weight, i.r., viscosity, density and pour point have been determined for the prepared esters.

Some physico-chemical behaviors and correlations have been deduced to characterize the prepared esters. Moreover, they shed the light on their suitability as base oils which may be used in formulations according to French Air specification 3514 (Nato 0–150) as compared with the commercial oil sample (Trubonycoil 13B) used in this respect.

1. Introduction

Synthetic lubricants are used for applications where a lubricant must perform under conditions that go beyond the capabilities of mineral oil lubricants. Gas turbine engines are working under these conditions which mostly are considered to be severe.

The synthetic turbo oils are formulated to obtain the following characteristics [1–5];

- High thermal stability at elevated temperatures.
- High resistance to oxidation.
- Low deposit formation tendencies.
- High viscosity index (minimum change in viscosity with wide changes in temperature).
- Low volatility (minimizes lubricant evaporation losses at high temperatures and low pressures).
- High flash point.
- High load carrying capability (to minimize wear).
- High resistance to foaming.

Use of some synthesized organic esters verifies these characteristics.

An ester is the product created by the chemical reaction of an organic acid with an alkanol. This can be simply shown as follows:

$$\text{organic acid} + \text{alkanol} \xrightarrow{\text{heat}} \text{ester} + \text{water}$$

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The components used in turbo-oils are more complex. The esters of polyols are considered to be the most familiar [1,6–15]. Some of polyol esters and or the mixed are the bases which are used generally with special additives in blending the synthetic turbo-oils for light weight gas turbo-engines of air crafts [1,2,5].

This is due to their properties to achieve the desired characteristics for long service and high performance according to international specifications.

1.1. Types of lubricants

The lubricants used in aircraft gas turbines are designated [1] either:

- By their viscosity at 98.9°C (210 °F), which are 3, 5 and 7.5 Cst.
- Or by their military or civil specifications as shown in Table 5.

These synthetic lubricants may be broadly classified, on the pattern suggested by Dukek [16], as follows;

1.1.1. Type I-oils

Type I-oils are generally based on dibasic esters fortified with viscosity index improvers and antioxidants. Formulations of such oils are being constantly improved to obtain oils of better thermal and oxidation stability. This type is generally considered to be satisfactory for applications where the bulk oil temperature is less than 200°C. They can be used in turbo-prop aircraft if they are blended or thickened with complex esters (or polymers) to meet the required viscosity of 7.5 CSt at 98.9°C.

1.1.2. Type II-oils

This type is generally based on ‘‘hindered’’ polyol esters. These oils also contain antioxidants and anticorrosion agents. They can operate satisfactorily in bulk oil temperature range of 200–260°C and with speed regime Mach 1 to Mach 2 aircrafts.

1.1.3. Type III-oils

Type III oils represents the ultimate possibilities in practical synthetic oils that can be currently visualized. One type of such oils is polyphenyl-ether [1–3,8,17], which might yield stable base stoke with better viscosity characteristics and high thermal degradation (400°C) with good oxidation resistance.

The silahydrocarbons are competitive in these properties [18,19]. Type III may be used in aircrafts operating in the speed regimes of Mach 3 or above. They can operate at temperatures exceeding 260°C.

2. Experimental

2.1. Raw materials

Pentaerythritol, *n*-buteric, *n*-heptanoic, and *n*-nonanoic carboxylic acids, (Mx_2), catalyst and xylene, all are of reagent grades and used as received.

2.1.1. Preparation of polyol esters

In this work several polyol esters have been prepared by the esterification of pentaerythritol [PE] with saturated monocarboxylic acids having carbon atom number C_4, C_7 and C_9. In a previous work [6,7] the conditions have been chosen to be as follows;

- Temperature: 170 ± 0.1°C.
- Molar ratio (alcohol:acid): 1:4.9
- Catalyst concentration: 2% wt (based on alcohol).
- Agitation rate: 550 r.p.m.
- Azeotropic agent: xylene.

Table 1 Experimental data for the preparation of pentaerythritol esters.

Time in hours	Pentaerythritol esters		
	Tetrabutyrate % Conversion	Tetraheptanoate % Conversion	Tetranonanoate % Conversion
1.0	49.4	47.5	46.4
2.0	77.2	73.1	72.3
3.0	89.2	86.3	85.2
4.0	94.3	90.9	89.1
5.0	98.8	95.0	94.2
6.0	–	98.2	97.1

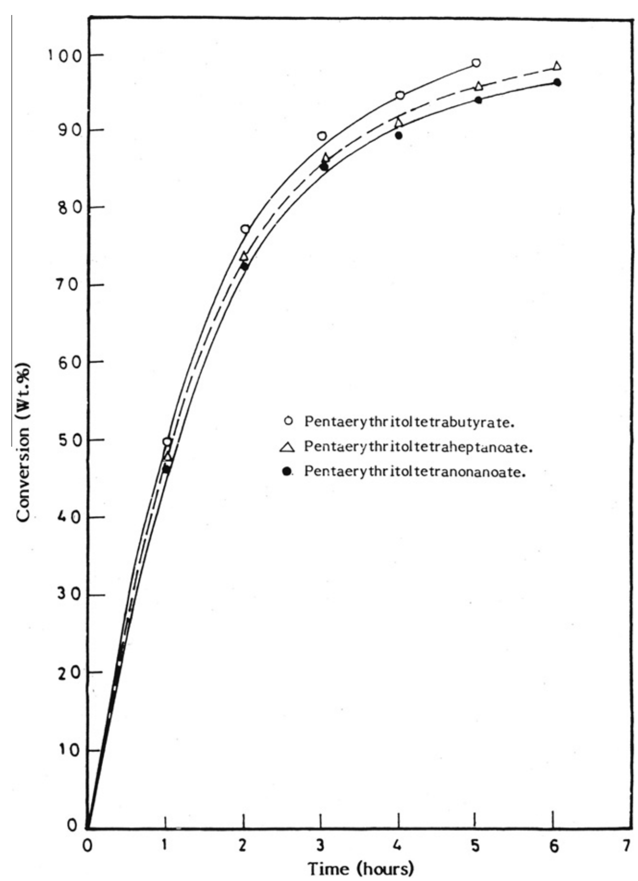

Figure 1 Conversion (wt. of H_2O collected) versus esterification time for pentaerythritol esters [Temp. 170 °C, molar ratio (alcohol to acid) 1:4.9, catalyst conc. 2% (by wt) of polyol and agitation 550 r.p.m.].