

Chemical reconstruction of Castor Oil —Research of Environmentally Friendly Lubricants

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Abstract: Natural castor oil was chemically reconstructed to extend the carbon chains by means of iso-reaction so as to improve the rheological behavior by way of increasing the viscosity index and decreasing the pour point. The rheological and tribological characteristics of the reconstructed castor oil were comparatively investigated with those of the natural castor oil and several other vegetable oils and a mineral oil. The friction and wear test results on a four-ball machine indicate that the chemically reconstructed castor oil has considerably improved rheological and tribological properties as compared with the natural castor oil. It shows a greatly increase viscosity index and largely decreased pour point, which makes it applicable to low temperature lubrication. The chemically reconstructed castor oil even shows better tribological behavior than pentaerythritol ester or di-iso-capryl sebacate. However, it is still needed to increase the oxidation stability of the reconstructed castor oil.

Key words: castor oil; chemical modification; environmentally friendly lubricants; rheological characteristics; tribological characteristics

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1. Introduction

The plants oils had been done as lubricants since anciently, which is biodegraded like synthetic esters easier than petroleum. It can be regarded as environmentally friendly (green) lubricants^{[1][2]}. On the other hand, the plant oils is thought over as the outcome of the sunny energy, which is used endlessly. But, the plant oils have some shortcoming, such as the high pour point, the less viscosity index than synthetic esters.

It's assumed that natural castor oil is chemically reconstructed to which makes use of the iso-reaction and the extend carbon chains of reaction so that the viscosity index hope to be improved and the pour point be decreased in this paper.

It's made know on the test result that chemically reconstructed castor oil have excellent characteristic : its V_{40C} 150mm²/s highly, its pour point less than -40°C, its VI 150 over.

2. Mechanism on chemically reconstructed castor oil

The main component of natural castor oil is glyceride 12-hydroxyl oleate, which have one hydroxyl more than common plant oil. So, there is distinguished metal absorbing activity and excellent lubrication on castor oil, which is

often used lubricating the difficult cutting stainless steel. The plant oil is biodegraded easier than mineral oil, because there are glyceride fatty acid.

The viscosity of castor oil is usually higher than common plant oil (V_{40C} is about 210 mm²/s). Its viscosity index (VI=70 mm²/s or so) is worse than the bean oil and rapeseed oil (VI for 175 and 208 mm²/s^[1]). Its rheological character have been improved largely. Its antiwear and friction coefficient are better than the same viscosity of mineral oil; little better than pentaerythritol esters or Di-iso-capryl sebacate by four ball test.

The viscosity index of rapeseed oil is very high, because there are about 40 percents of long carbon chains of glyceride twenty-two carbon atoms unsaturating fatty acid in it (It's four carbon atoms more than eighteen carbon atoms in common plant oil). It's conceived that acetic acid esterifies castor-oil acid on the position of its 12- hydroxyl so that the product of ester increases two carbons because of iso-reaction.

The viscosity index of lubricants is improved along with carbon increased according to the rule of chemical structure. The pour point can be decreased according to the rule of branching reaction. The lubricant character of product is corresponded to the request of excellent synthetic lubricants.

3. Synthetic Method

The fresh castor-oil is reacted with equivalent acetic acid on the condition of decreasing pressure, heating and removing the reactive water in the according of the groovy way of esterification. The formula of reaction is shown in the follow. The reaction product is washed by hot water three times. The underlayer is washed out until get neutral, then the chemically reconstructed castor oil is attained after the upper oil is dried out.

4. The Rheological and Frictional Characteristic of Chemically Reconstructed Castor Oil

The rheological characteristic of chemically reconstructed castor oil and other lubricant base fluids is listed on the table 1. The other lubricants are natural castor oil, bean oil, rapeseed oil, pentaerythritol esters(C_{7-9} Acidate), Di-iso-capryl sebacate and mineral oil VG150# as compared oil.

The viscosity of chemically reconstructed castor oil is near to mineral oil VG 150#, but its viscosity is still high. The viscosity index is improved from 70 to 175 and the pour point is reduced from -19°C to $< -40^{\circ}\text{C}$. The rheological characteristic of chemically reconstructed castor oil is little better than pentaerythritol esters(C_{7-9} Acidate) and further better than mineral oil and the other plant oil. There is eximious performance of the rheology for Di-iso-capryl sebacate, but its $V_{40^{\circ}\text{C}}$ is very low, so its range of application is narrow. It is done as instrument base oil or blending components of the synthetic lubricants. Then all kinds of viscosity grade, low pour point and high VI of lubricants are also get mixed with chemically reconstructed castor oil and di-iso-capryl sebacate to definite proportion on the other hand.

The frictional characteristic of chemically reconstructed castor oil and natural castor oil, bean oil, rapeseed oil, pentaerythritol esters(C_{7-9} Acidate), Di-iso-capryl sebacate and mineral oil VG150# as compared oil is listed on the figure1 and figure2. The delta wear result is shown in Fig. 1 under different loads 98N, 196N, 294N, 392N, 441N. Four numbers each group is shown in Fig.1 and Fig.2 because the test data under 441N is defected.

Antiwear of chemically reconstructed castor oil is not improved only higher than natural castor oil under different loads because of the delta diameter becoming small, but also better than the other lubricants in the Fig.1. The friction

coefficient is smaller than The other lubricants, especially under heavy loads(392N~441N) on the steel pair. The viscosity of Mineral oil 150# is similar to chemically reconstructed castor oil, but its lubrications is bad.

5. Conclusion

The viscosity-temperature characteristic of chemically reconstructed castor oil is evidently improved and the pour point is reduced by the way of isomerization of castor oil. So the rheological characteristic had greatly been meliorated.

The lubricants characteristic (wear scar diameter and frictional coefficient for four ball test) of chemically reconstructed castor oil had been also improved. The character is regarded little better than pentaerythritol esters.

The chemically reconstructed castor oil is environmentally friendly lubricants as the same as synthetic esters, which is enough to lubrication of low temperature.

But the facile oxidation of chemically reconstructed castor oil isn't solved because the unsaturated bonds is not disappeared, which can't be fit for lubricants of the high temperature.

6. REFERENCES

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