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Thermo-Oxidatively Improved Environmental Friendly Base Oils

TRACK OR CATEGORY
7K Nonferrous Metals - Biobased

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INTRODUCTION
Vegetable oils have been used in lubricant industry as base oil because of its unique characteristics viz., high viscosity index, higher flash points and low coefficient of friction and also due to reasons of environmental friendliness. However, since individual vegetable oil alone is not suitable to achieve complex lubricant requirements including thermo-oxidative stability, blends of differently stable vegetable oils and blends with other highly stable base oils like esters and diluents are options for getting the desired performance.

This presentation is focusing on studies on mixtures of differently stable vegetable oils and blends of vegetable oils with a highly stable ester for obtaining bio base oils with improved thermo-oxidation characteristics. Based on the detailed investigation carried out on blends of different vegetable oils and mixtures of vegetable oils with ester base oil and a diluent, the lecture will give details of studies on thermo-oxidative stability by various techniques, low temperature fluidity, tribological performance and biodegradability of the innovative vegetable oils combinations.

Background

Some inedible vegetable oils of Indian origin with potential for lubricants application were studied and found to be promising candidate vegetable oils as lubricant base oils. In physico-chemical, hydrolytic stability and tribological performance they were found to be better compared to conventionally used synthetic esters and vegetable oils.

Properties	Jatropha	Dilo	Castor	Gp I Mineral oil
Viscosity,@40 ^{0}C,cSt.	35.8	31.2	220.6	29.2
Viscosity, 100^{0}C,cSt.	8.04	7.5	19.7	5.14
Viscosity Index	208	220	102	105
Saponification Value	197	190	180	Nil
Pour Point ^{0}C	0	+6	<(-)27	(-)3
Flash Point, ^{0}C	240	223	>250	224
Coef. of Friction by SRV Machine, 100N, 50C,50Hz,1mm,1 Hr	0.08	0.09	0.08	0.11

Thermo-oxidative stability was studied by RPVOT methods at different severities:

1. RPVOT as per ASTM D-2272:150 ^{0}C; Cu Catalyst; Water (Severe oxidation conditions)
2. Modified RPVOT II: Temperature 120 ^{0}C with Cu Catalyst , No Water (Medium)
3. Modified RPVOT I : Temperature 120 ^{0}C; No Cu Catalyst & Water (Mild)

In the above tests the oils performed better than some synthetic esters and other vegetable oils considered for comparison. Castor oil has shown comparatively exceptionally higher degrees of thermo-oxidative stability due to very high content of monounsaturation. However, compared to mineral oils, these oils needed improvement. Selection of suitable antioxidants and blending with mineral oils and synthetic esters were explored for this. All the mineral oil added vegetable oil blends showed much superior oxidation stability compared to the vegetable oil itself. GpI oil blended vegetable oils showed higher oxidation stability than and GpII and GpIII blended vegetable oils. Mineral oil blending in castor oil is not possible due to incompatibility.

EXPERIENTAL

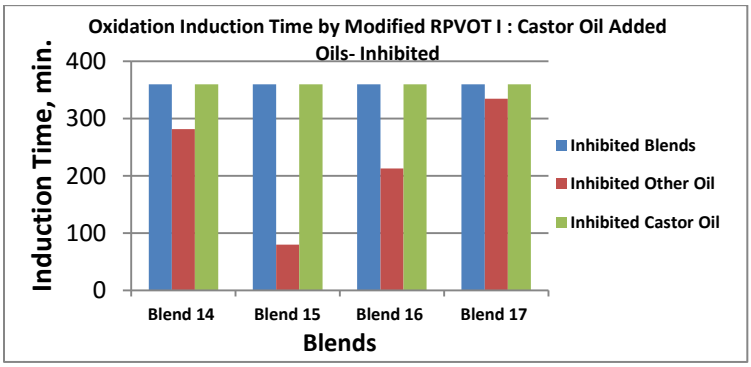
Blends of Vegetable Oils of Varying Thermo-oxidative Stability- Castor Oil with Other Vegetable Oils

Castor oil having very high viscosity ~ 200 cSt. at 40 ^{0}C is not suitable as such for most of the lubricant application. With higher thermo-oxidative stability and higher viscosity, castor oil can be blended with other less stable low viscosity vegetable oils to get potentially thermo-oxidatively improved bio base oil.

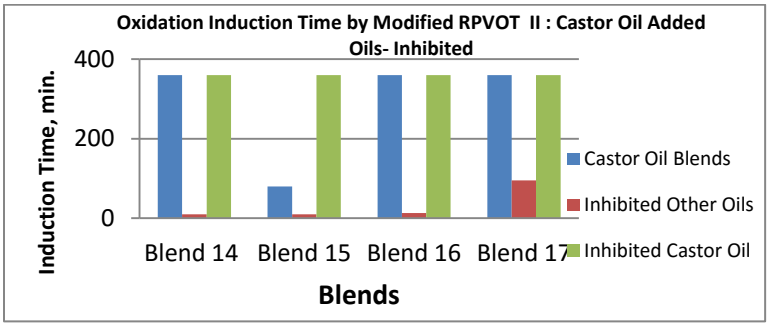
Castor Oil Added Blends with Other Oils for the Study

Oils	Blend 10	Blend 11	Blend 12	Blend 13
	%wt.	%wt.	%wt.	%wt.
Castor	50.0	50.0	50.0	50.0
Rapeseed	50.0	----	----	----
Soybean	----	50.0	----	----
Jatropha	----	----	50.0	----
Dilo	----	----	----	50.0

The above blends were studied under varying degrees of oxidizing conditions as mentioned above. **Without antioxidant**, it was observed that blending of castor oil with less stable other vegetable oil fetched no positive result in oxidation stability. **Inhibited blends** of castor oil added in other oils and were studied for thermo-oxidatve stability in different conditions: Mild to severe oxidation conditions. In the mild oxidizing conditions the inhibited blends were found to be significantly better in thermo-oxidative stability compared to non-blended inhibited oils: induction time crossed the maximum time considered in the study i.e., 360 min as in the castor oil itself. Even the soybean oil with very low induction time crossed this value of 360 min along with castor oil.



In medium oxidation conditions, inhibited castor oil added blends with other vegetable oils, except soybean oil blend, showed significantly better in thermo-oxidative stability under medium oxidation conditions compared to non-blended inhibited oils.

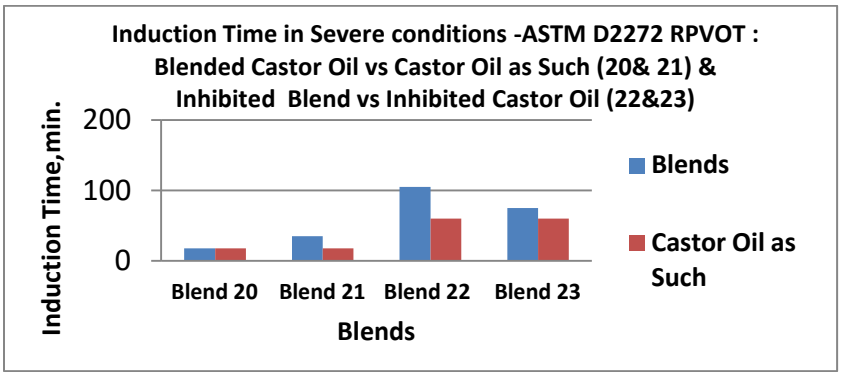


Under severe oxidation conditions of RPVOT as per ASTM D-2272 conditions, all oil blends with castor oils failed to give acceptable levels of induction time. Therefore for high performance applications castor oil blends with low viscosity Gp II mineral oil and a stable ester were explored.

Stable Castor Oil Blends Studied for High performance

Oils	Blend 20	Blend 21	Blend22	Blend 23
	%wt.	%wt.	%wt.	%wt.
Castor Oil	31	74	30.5	73
Mineral Oil	32	12	31.5	12
Ester	37	14	37.0	14
Antioxidant	0	0	1.0	1.0

The inhibited castor oil blends selected for high performance application showed much higher induction values than inhibited castor oil.



Low Temperature Fluidity, Tribological Properties and Biodegradability of Blends

Improvement in low temperature fluidity of vegetable oil mixed with mineral oil and esters was limited showing only a decrease of maximum 6 ^{0}C. The same was observed in the case of castor oil added other vegetable oil blends. Suitable pour points needs to be explored for achieving lower pour points. Blends of vegetable oils with mineral oils showed lower coefficient of friction and very good biodegradability in the range of 90 %, much higher than the expected average.

Based on above study the blends of vegetable oils with mineral oils and synthetic esters were found better options for biobase oil. The physico-chemical properties, tribological properties and biodegradability of these blends were also determined by the standard ASTM methods and compared with Gp I mineral oils and they were found to be suitable for application as base oils in environmental friendly lubricants.

Properties	Jatropha Oil + GpI Oil	Jatropha Oil + GpII Oil	Castor Oil + Ester + GpII Oil (Low viscosity)	Castor Oil + Ester+ GpII Oil(High viscosity)
Appearance	Clear Liquid	Clear Liquid	Clear Liquid	Clear Liquid
Kin. Viscosity at 40 ^{0}C,cSt.	31.3	31.3	27.2	108.5
Kin. Viscosity at 100 ^{0}C, cSt.	6.27	6.33	5.15	11.6
Viscosity Index	156	158	120	94
Sap. value, mg.KOH/g	98	98	153	170
Iodine Value, mg.I/100g	48.5	48.5	27	64
Pour point, ^{0}C	+3	(- 6)	(- 27)	(- 27)
Flash Point, ^{0}C	>210	>210	>210	>230
Coefficient of Friction	0.09	0.09	0.10	0.08
Biodegradability,%	89	90	89	97

CONCLUSIONS

The studies on different approaches explored for thermo-oxidatively improved vegetable oils have concluded:

- ✓ Mineral oil added vegetable oil blends showed much superior oxidation stability compared to the vegetable oil itself. Gp I oil blended vegetable oils showed higher oxidation stability. With antioxidants the much higher effect of blending was achieved
- ✓ Castor oil can be blended with other less stable low viscosity vegetable oils to get thermo-oxidatively improved bio base oil. In the mild and medium oxidizing conditions the inhibited blends were found to be significantly better in thermo-oxidative stability compared to non-blended inhibited oils
- ✓ For severe oxidizing conditions the blends of castor oil with mineral oil and ester has proven to be remarkably thermo-oxidatively improved environmental friendly base oil

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KEYWORDS

Thermo-oxidative stability, environmental friendly lubricants, biodegradability