## Direct synthesis of bio-lubricant by the oligomerization of methyllinoleate via castor oil

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## Preparation of methyl ricinoleate

The castor oil is used to prepare methyl ricinoleate, with the molar ratio of 0.2:1 between castor oil and methanol. The preparation procedure is detailed below: First, the castor oil (100 g) is kept at 413 K for 2 hours to remove water, then kept at 303 K. At the same time, the metered NaOH (5 g) is dissolved in anhydrous methanol (17.2 g) to prepare a NaOH methanol solution. When the temperature of castor oil was stabilized at 303 K, the prepared NaOH methanol solution was quickly mixed with castor oil, and the reaction was kept stirring for 6h. After the reaction is completed, add the acetic acid (11 g) to neutralize the NaOH, heat to 353 K to evaporate the methanol, then transfer the reaction solution to a separatory funnel for liquid separation. The lower layer is water and glycerin and impurities, the upper layer is methyl ricinoleate. After the liquid separation, the upper layer was washed four times with water until the pH of the washing liquid reached that of the distilled water, and the residual water was distilled off under reduced pressure to obtain ricinoleic acid as a transparent yellow liquid. The yield of methyl ricinoleate was calculated to be 96% from the ratio of methyl ricinoleate and castor oil.



Figure S1 N<sub>2</sub> Adsorption-desorption isotherms at 77K for representative catalysts (a) 9SiO<sub>2</sub>-1Al<sub>2</sub>O<sub>3</sub>, (b)3%MoO<sub>3</sub>/9SiO<sub>2</sub>-1Al<sub>2</sub>O<sub>3</sub>

Figure S1 shows the N<sub>2</sub> adsorption–desorption isotherms for the as-synthesized  $3\%MoO_3/9SiO_2-1Al_2O_3$  and the typical catalysts after loading MoO<sub>3</sub> species, which shows a type II hysteresis loop in the  $p/p_0$  range of 0.5-1.0 according to the IUPAC classification. The BET surface area of  $9SiO_2-1Al_2O_3$  decreased from 406.6 to  $338.8 \text{ m}^2/\text{g}$  after loading MoO<sub>3</sub> on the  $9SiO_2-1Al_2O_3$  ( $3\%MoO_3/9SiO_2-1Al_2O_3$  catalyst). The reduction in BET surface area after loading metal could be possibly attributed to the formation of MoO<sub>3</sub> nanoparticles which blocks or fills the pore channel of the support.



Figure S2. SEM images of the as-synthesized  $9SiO_2-1Al_2O_3$  (a) and the  $3\%MoO_3/9SiO_2-1Al_2O_3$  (b).



Figure S3. HR-TEM images(a, b), SAED patterns(c) and EDS data(d) for 3%MoO<sub>3</sub>/9SiO<sub>2</sub>-1Al<sub>2</sub>O<sub>3</sub> catalyst.



**Figure S4.** GPC analysis of the dehydro-oligomerized product of methylricinoleatein over catalysts of 3%MoO<sub>3</sub>/9SiO<sub>2</sub>-1Al<sub>2</sub>O<sub>3</sub>. Retention volumes of peaks marked a, b, and c correspond to molecular weights around 300, 600, and 900, respectively



Figure S5 Mass spectrum of the dehydro-oligomerized product of methylricinoleatein.



Scheme S1. Dimerization of methyl linoleate contained the double bonds in the 9,11

Fluid	Viscosity, cSt at 40 °C	Pour points, °C
Soybean oil <sup>1</sup>	31.5	-9
90% Oleic Sunflower oil <sup>1</sup>	40.3	-12
castor oil (this work)	246	-21
Oligomer of methyllinoleate (this work)	27.9	-42
PAO <sup>1</sup>	17.4	-63
Mineral oil <sup>1</sup>	71.2	-21

Table S1 Viscosities and pour points of major lubricating basestocks

## Supplementary References

(1) S. Z. Erhan and S. Asadauskas, Ind. Crop. Prod., 2000, 11, 277-282.

Sample _	Total acid sites (423 K)		Medium and strong sites (623 K)	
	В	L	В	L
7%MoO <sub>3</sub> /SiO <sub>2</sub>	0.001	0.061	0.001	0.014
7%MoO2/Al2O2	0.001	0.001	0.001	0.014
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	0.035	0.102	0.011	0.062
3%MoO <sub>3</sub> /9SiO <sub>2</sub> -1Al <sub>2</sub> O <sub>3</sub>	0.157	0.202	0.079	0.092

Table S2 Acid site distribution of the samples (mmolg<sup>-1</sup>).

1 of 10