SUPPLEMENTARY INFORMATION

Lipophilic molecular rotor to assess the viscosity of oil core in nano-emulsion droplets

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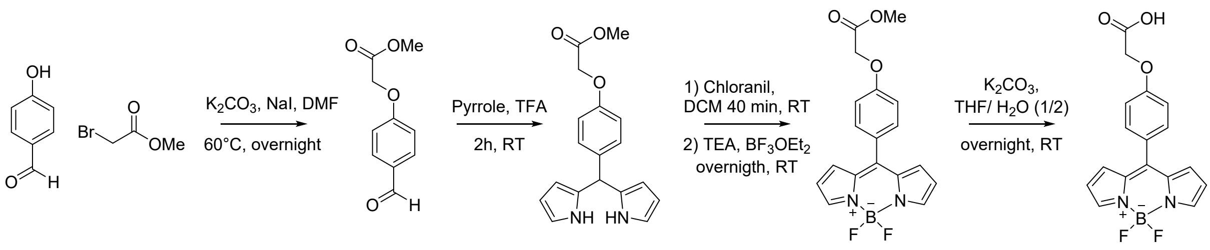
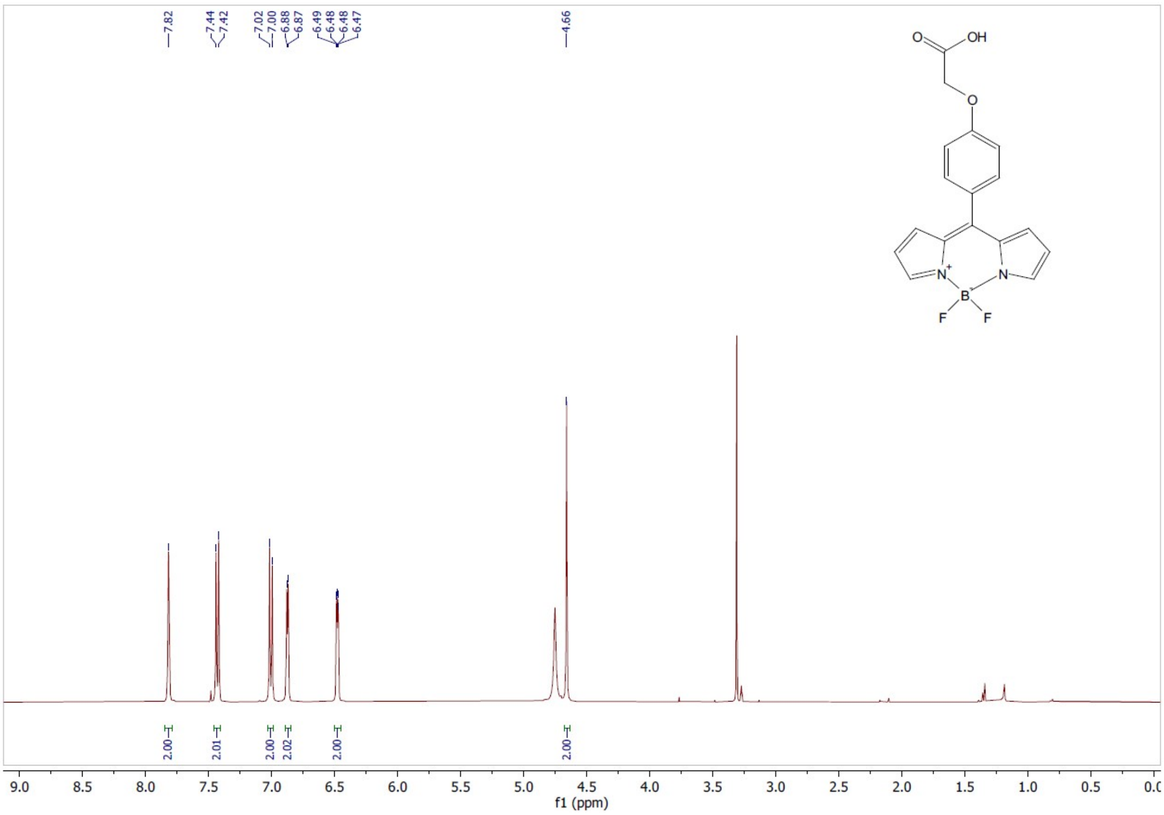
1. Synthesis of BODIPY rotor acid:

BODIPY rotor acid was synthesized according to previous report [1]



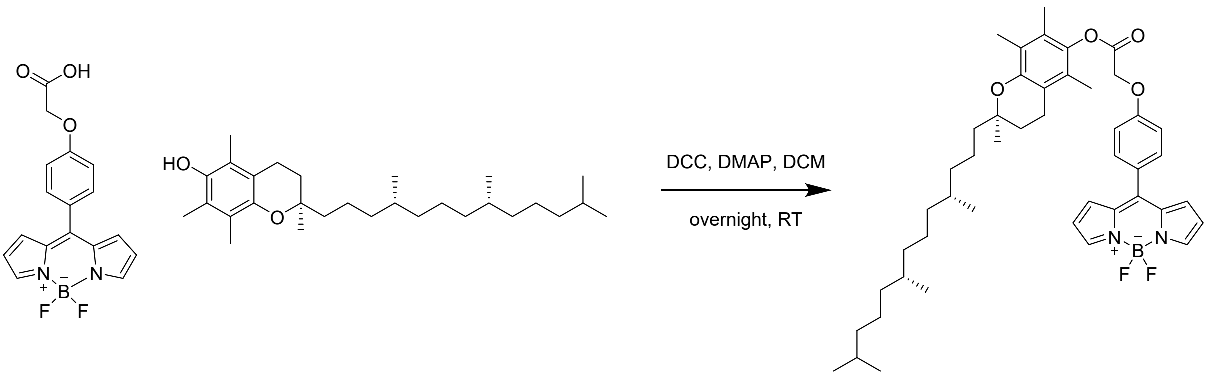
[1] Ashokkumar, P.; Ashoka, A. H.; Collot, M.; Das, A. A fluorogenic BODIPY molecular rotor as an apoptosis marker, *Chem. Commun.*, **2019**, 55, 6902-6905.

^{1}H NMR (400 MHz, CD_3OD-$CDCl_3$ $_{1\text{-}1}$) δ 7.82 (s, 2H, H pyrrole), 7.43 (d, *J* = 8.8 Hz, 2H, H phenyl), 7.01 (d, *J* = 8.7 Hz, 2H, H phenyl), 6.87 (d, *J* = 4.2 Hz, 2H, H pyrrole), 6.48 (dd, *J* = 4.3, 2.0 Hz, 2H, H pyrrole), 4.66 (s, 2H, CH_2).



2. Synthesis of BODIPY rotor tocopherol:

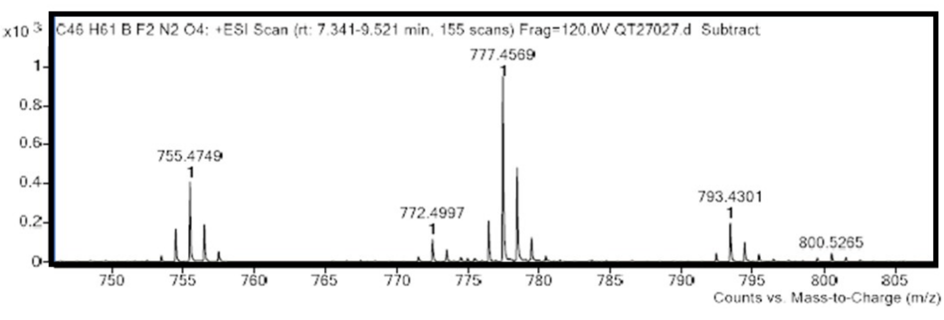
To the solution of bodipy-acid (173 mg, 0.5 mmol, 1 equiv.) dissolved in dry DCM (5 mL) was added (R)-2,5,7,8-tetramethyl-2-((4R,8R)-4,8,12-trimethyltridecyl)chroman-6-ol (322 mg, 0.75 mmol, 1.5 1 equiv.), DCC (124 mg, 0.6 mmol, 1.2 equiv.) and DMAP (12 mg, 0.1 mmol, 0.2 equiv.). The reaction mixture was stirred at room temperature overnight. The mixture was diluted with DCM and washed with water and brine, dried over MgSO4, filtered, and the solvent was removed in vacuo. The residue was purified by flash column chromatography (Heptane/40-50% DCM) to give Bodipy-rotor-tocopherol as a red oil (100 mg, 0.1 mmol, 26 %).

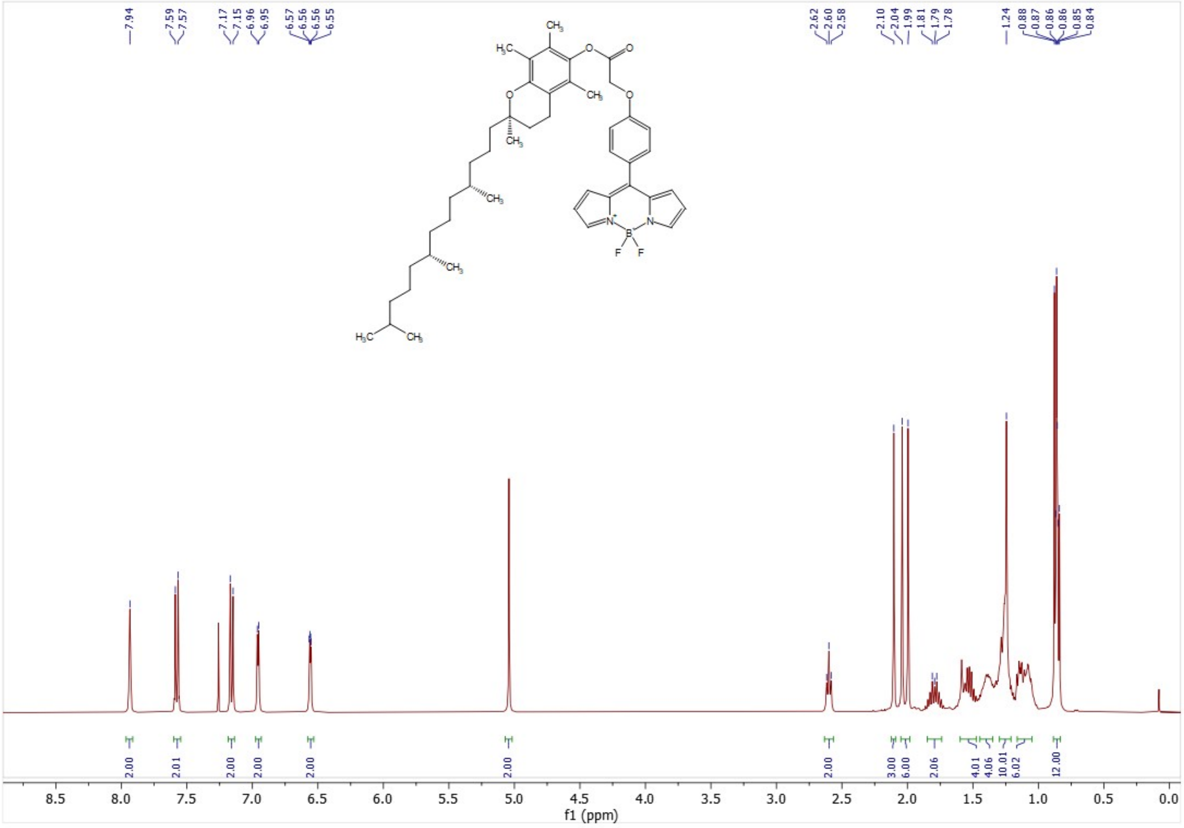


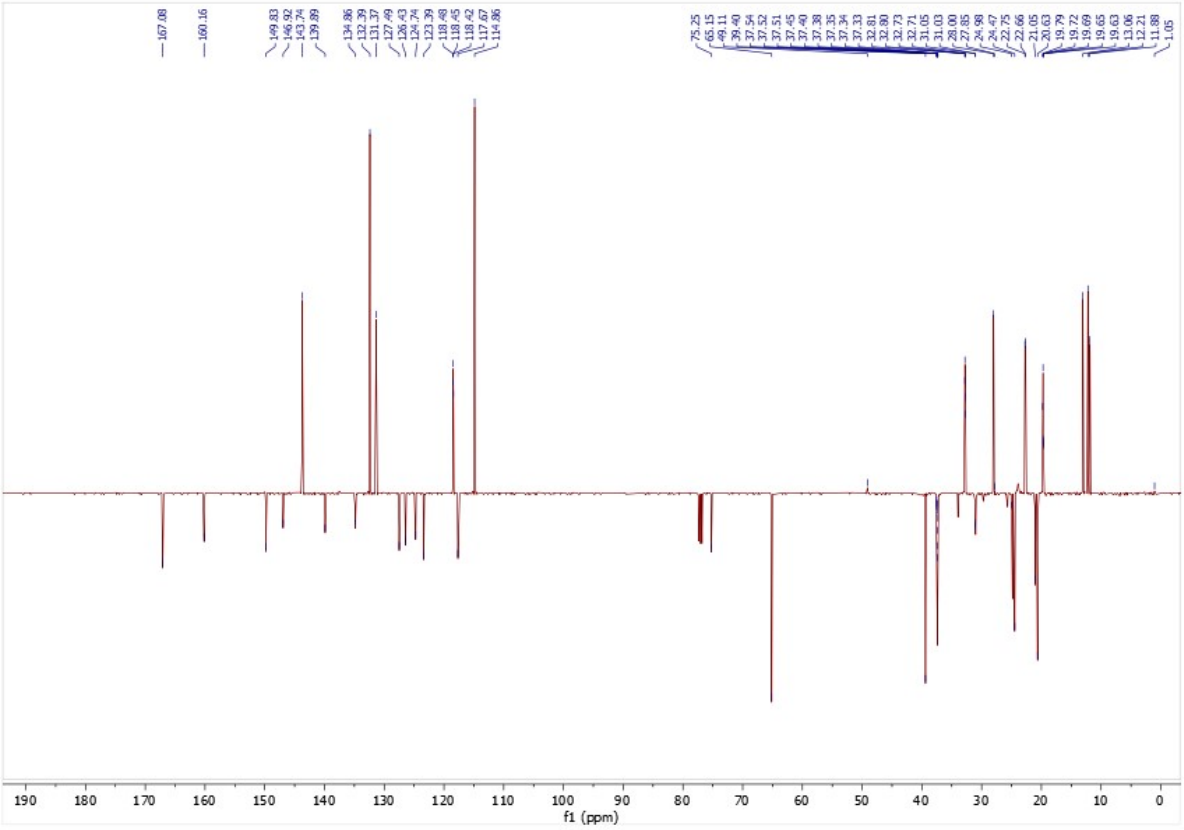
HRMS (ESI+): m/z calculated for C46H61BF2N2O4 M: 753,4729, found M+H: 755.4749, M+NA: 777.4569, M+K: 793.4301

1H NMR (400 MHz, CDCl3) δ 7.94 (s, 2H, H pyrrole), 7.58 (d, J = 8.7 Hz, 2H, H Phenyl), 7.16 (d, J = 8.8 Hz, 2H, H Phenyl), 6.96 (d, J = 4.2 Hz, 2H, H pyrrole), 6.56 (dd, J = 4.2, 1.9 Hz, 2H, H pyrrole), 5.04 (s, 2H, CH2), 2.60 (t, J = 6.8 Hz, 2H, CH2 Oxane), 2.10 (s, 3H, CH3 Benzyl), 2.02 (d, J = 18.0 Hz, 6H, CH3 Benzyl), 1.85 – 1.74 (m, 2H, CH2 Oxane), 1.60 – 1.47 (m, 4H), 1.45 – 1.35 (m, 4H, CH and CH2 aliphatic), 1.24 (m, 10H, CH3-Oxane and CH2 aliphatic), 1.16 – 1.05 (m, 6H, CH2 aliphatic), 0.89 – 0.83 (m, 12H, CH3 aliphatic).

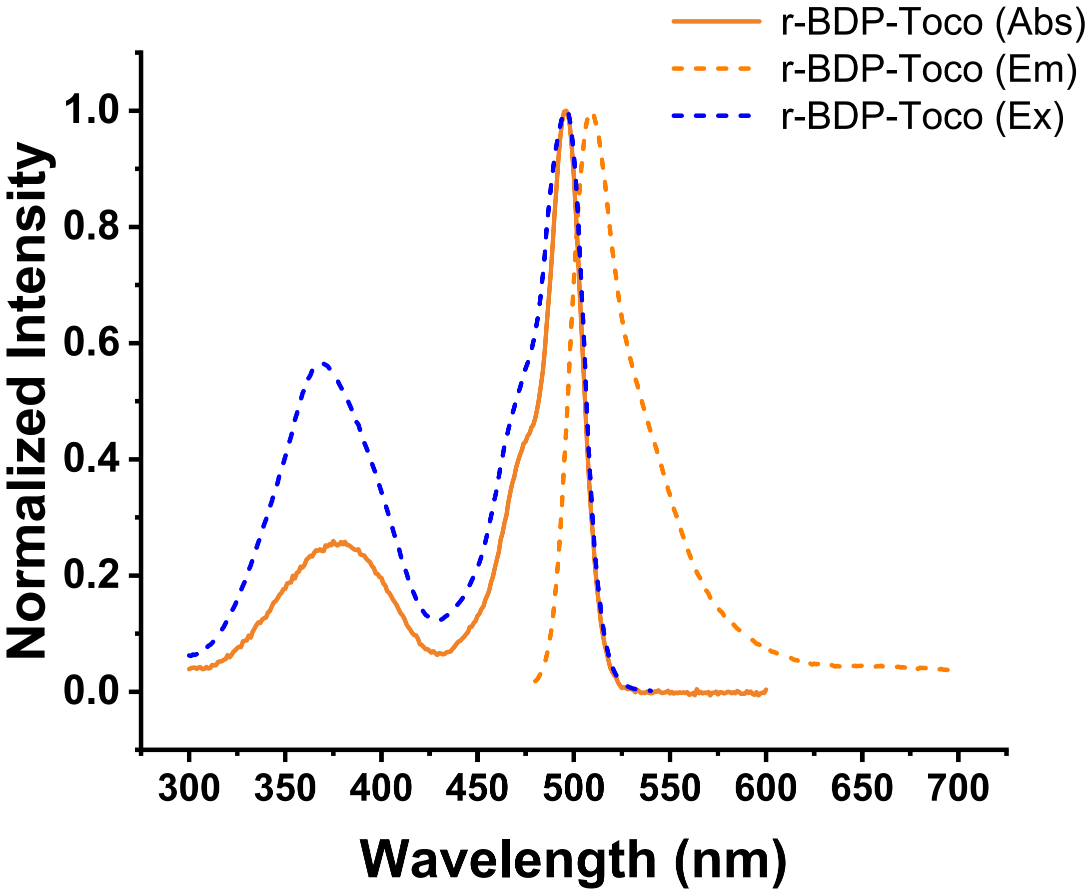
13C NMR (126 MHz, CDCl3) δ 167.08 (C=O), 160.16, 149.83 (C-O), 146.92 (C-N), 143.74 (C=C-O), 139.89, 134.85, 132.39, 131.37, 127.49, 126.43, 124.74, 123.39, 118.48, 118.45, 118.42, 117.67, 114.86 (C=C), 75.25 (Cq), 65.15 (CH2), 49.11, 39.4, 37.56, 37.47, 37.42, 37.38, 37.31, 32.81, 32.80, 32.73, 32.71, 31.03, 28.00, 24.98, 24.47, 22.75, 22.66, 21.05, 20.63, (CH et CH2 aliphatic) 19.77, 19.67, 19.64 (CH3 aliphatic), 13.06, 12.21, 11.88 (CH3-Benzyl).




7.94
7.59 7.57
7.17 7.15 6.96 6.95
6.57 6.56 6.56 6.55
2.62 2.60 2.58
2.10 2.04 1.99 1.81 1.79 1.78
1.24 0.88 0.87 0.86 0.86 0.85 0.84
2.00 2.01 2.00 2.00 2.00 2.00 2.00 3.00 6.00 2.06 4.01 4.06 10.01 6.02 12.00
f1 (ppm)


167.08
160.16
149.83 146.92 143.74 139.89
134.86 132.39 131.37 127.49 126.43 124.74 123.39 118.48 118.45 118.42 117.67 114.86
75.25 65.15 49.11 39.40 37.54 37.52 37.51 37.45 37.40 37.38 37.35 37.34 37.33 32.81 32.80 32.73 32.71 31.05 31.03 28.00 27.85 24.98 24.47 22.75 22.66 21.05 20.63 19.79 19.72 19.69 19.65 19.63 13.06 12.21 11.88 1.05
f1 (ppm)

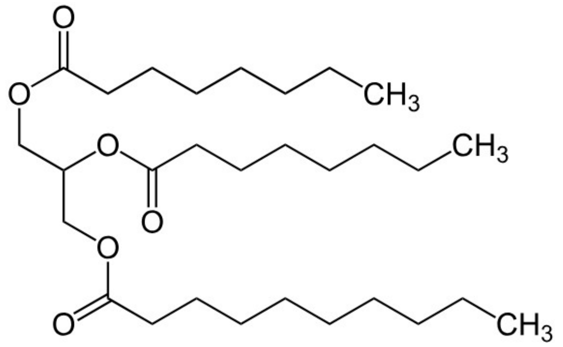
3. Spectral characterization of BODIPY rotor tocopherol



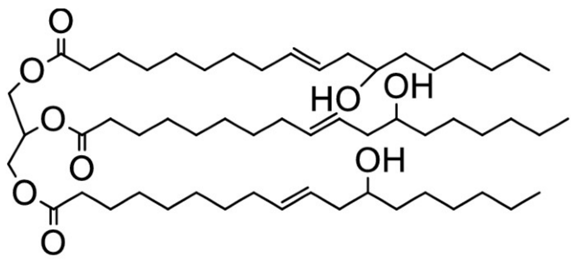
4. Chemical formulas of excipients used in the nano-emulsion formulations

Oil phases are composed of:

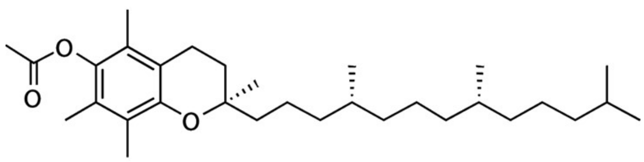
- *MCT (Labrafac® WL 1349)*



- *Castor oil*

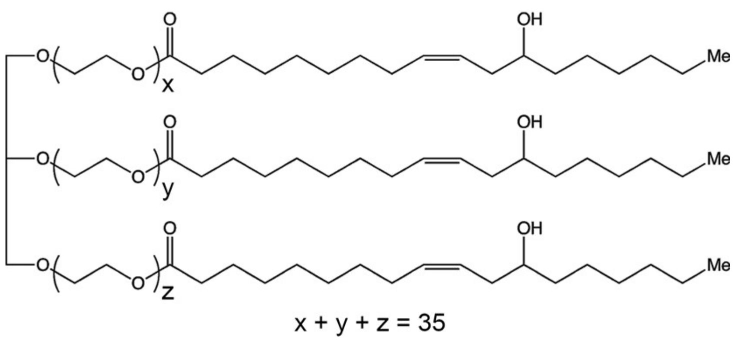


- *Vitamin E acetate*



Surfactant:

- *Kolliphor® ELP*



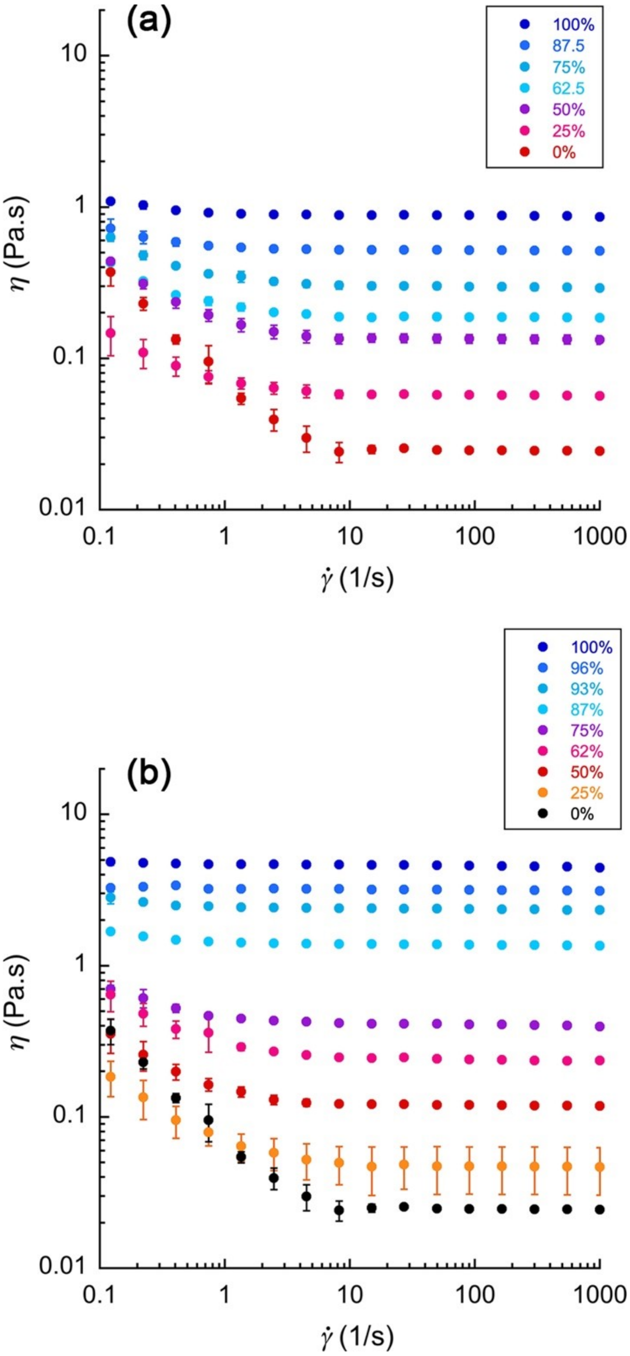


Figure S1: Dynamic viscosity (η) as a function of shear rate ($\dot{\gamma}$) obtained using an rotational rheometer, for different percentage of (a) castor oil, and (b) VEA, mixed with MCT.

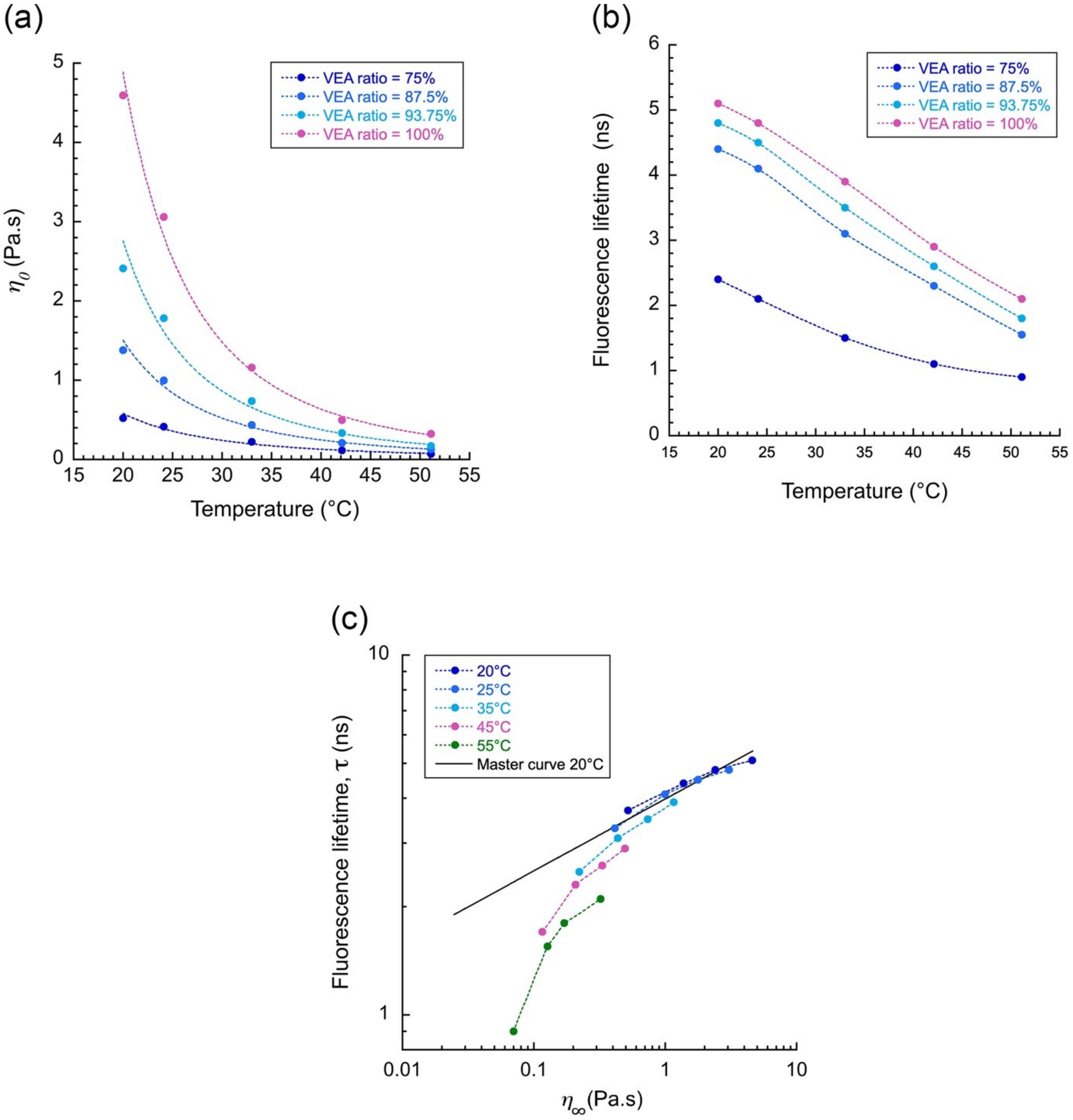


Figure S2: Study of the effect of temperature on rBDP-Toco molecular rotors, for VEA / MCT mixtures. (a) impact on viscosity, (b) impact on FLT, and (c) combination representing the relationship between viscosity and FLT and compared to the master curve at 20°C from Fig. 3.

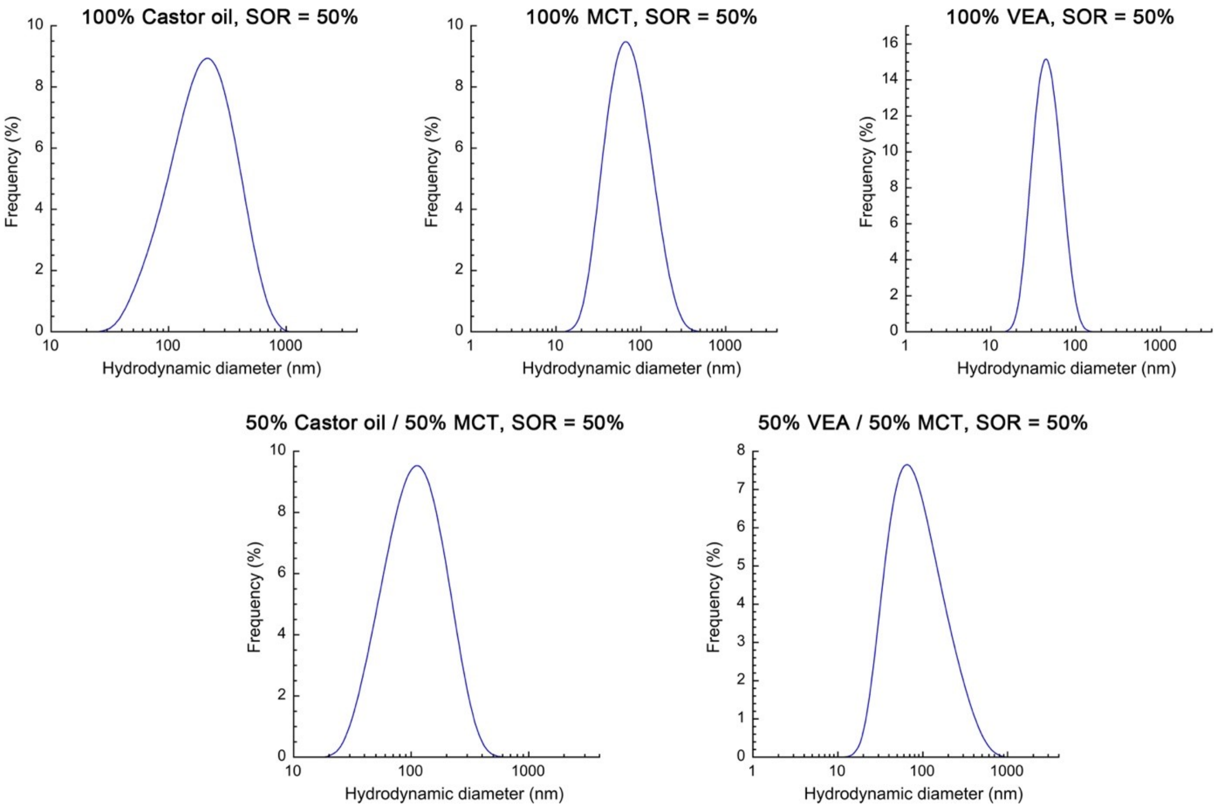


Figure S3: Size distribution of nano-emulsions obtained by DLS, for a panel of representative formulations.