

Article

Kinetical Study, Thermo-Mechanical Characteristics and Recyclability of Epoxidized Camelina Oil Cured with Antagonist Structure (Aliphatic/Aromatic) or Functionality (Acid/Amine) Hardeners

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Supplementary Materials

Table S1. Structure and characteristics of ECMO.

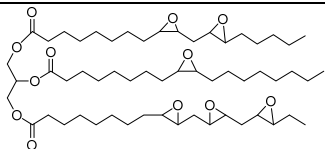
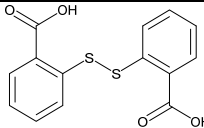
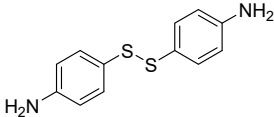
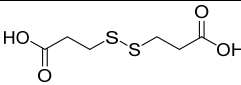
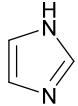
EVOs	Structure	Epoxy content (meq/g)	Mw (g/mol)
ECMO	 <p>Epoxidized Camelina Oil</p>	5.24	965
		Mw (g/mol)	Melting Point (°C)
DTBA	 <p>2,2'-Dithiodibenzoic acid</p>	306,35	287-290
4-AFD	 <p>4-Aminophenyl disulfide</p>	248.37	77-78
DTDA	 <p>3,3'-Dithiodipropionic acid</p>	210,27	155-158
IM	 <p>Imidazole</p>	68,07	88-91

Table S2. Acronyms and composition of formulations ECMO/DTBA_xDTDA_y - DTBA_x 4-AFD_y.

Formulations	Composition (% in mol)			mol		Mixing ratio of ELO: DTBA/4-AFD	IM (wt.%)
	DTBA	DTDA	ECMO	DTBA	DTDA		
ECMO/DTBA ₁₀₀	100	0	1.12·10 ⁻³	5.61·10 ⁻⁴	/	1:1	1
ECMO/DTBA ₇₀ DTDA ₃₀	70	30	1.12·10 ⁻³	3.93·10 ⁻⁴	3.36·10 ⁻⁴	1:1	1
ECMO/DTBA ₅₀ DTDA ₅₀	50	50	1.12·10 ⁻³	2.8·10 ⁻⁴	2.8·10 ⁻⁴	1:1	1
ECMO/DTBA ₃₀ DTDA ₇₀	30	70	1.12·10 ⁻³	3.36·10 ⁻⁴	3.93·10 ⁻⁴	1:1	1
ECMO/DTDA ₁₀₀	0	100	1.12·10 ⁻³	/	5.61·10 ⁻⁴	1:1	1
Formulations	Composition (% in mol)			mol		Mixing ratio of ELO: DTBA/4-AFD	IM (wt.%)
	DTBA	4-AFD	ECMO	DTBA	4-AFD		
ECMO/DTBA ₇₀ 4-AFD ₃₀	70	30	1.12·10 ⁻³	3.93·10 ⁻⁴	3.36·10 ⁻⁴	1:1	1
ECMO/DTBA ₅₀ 4-AFD ₅₀	50	50	1.12·10 ⁻³	2.8·10 ⁻⁴	2.8·10 ⁻⁴	1:1	1
ECMO/DTBA ₃₀ 4-AFD ₇₀	30	70	1.12·10 ⁻³	3.36·10 ⁻⁴	3.93·10 ⁻⁴	1:1	1
ECMO/4-AFD ₁₀₀	0	100	1.12·10 ⁻³	/	5.61·10 ⁻⁴	1:1	1

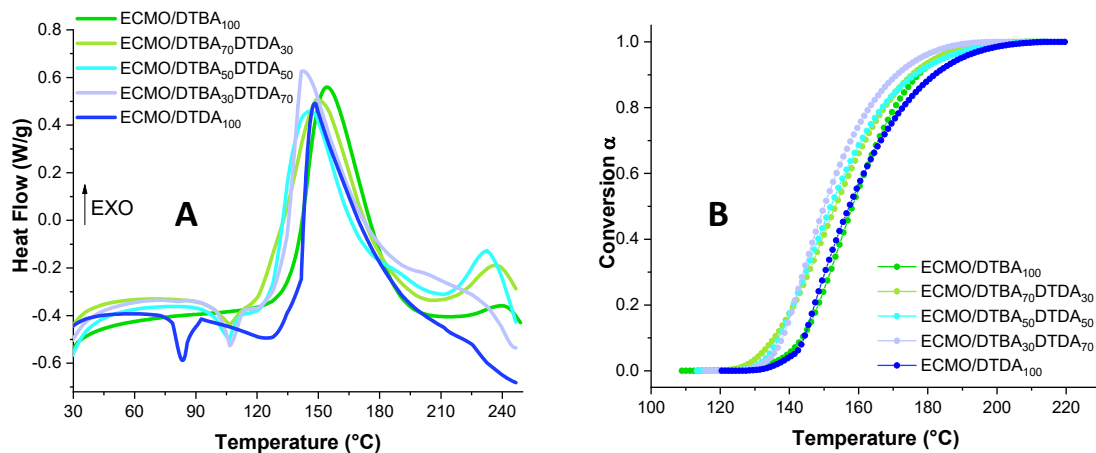









Figure S1. - DSC thermograms and degree of conversion α (B) for the ECMO bio-epoxy monomers combined with the diacids aromatic/aliphatic hardeners in R 1:1 and 1 wt.% of IM.

Table S3. DSC results for the ECMO/DTBA_xDTDA_y systems.

Materials designation	T_{on} (°C)	T_{peak} (°C)	T_{end} (°C)	ΔH (J/g)
ECMO/DTBA ₁₀₀	137	155	187	171
ECMO/DTBA ₇₀ DTDA ₃₀	126	150	182	168
ECMO/DTBA ₅₀ DTDA ₅₀	128	145	173	140
ECMO/DTBA ₃₀ DTDA ₇₀	135	143	175	156
ECMO/DTDA ₁₀₀	141	147	180	153

Table S4. Curing and post-curing protocol for the ECMO/DTBA_xDTDA_y and ECMO/DTBA_x4AFD_y systems.

Materials designation	Curing	Post-curing	Aspect
ECMO/DTBA ₁₀₀	130 °C – 60 min	170 °C – 30 min	
ECMO/DTBA ₇₀ DTDA ₃₀	130 °C – 60 min	170 °C – 30 min	
ECMO/DTBA ₅₀ DTDA ₅₀	130 °C – 60 min	170 °C – 30 min	
ECMO/DTBA ₃₀ DTDA ₇₀	130 °C – 60 min	170 °C – 30 min	
ECMO/DTDA ₁₀₀	140 °C – 60 min	180 °C – 30 min	
ECMO/DTBA ₇₀ 4-AFD ₃₀	120 °C – 60 min	160 °C – 30 min	
ECMO/DTBA ₅₀ 4-AFD ₅₀	20 °C – 60 min	160 °C – 30 min	



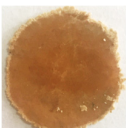
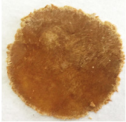

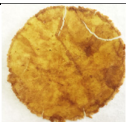





ECMO/DTBA ₃₀ 4-AFD ₇₀	120 °C – 60 min	160 °C – 30 min	
ECMO/4-AFD ₁₀₀	180 °C – 150 min	200 °C – 30 min	

Table S5. Reprocessing conditions and aspects of the reprocessed ECMO/DTBA_xDTDA_y and ECMO/DTBA_x4AFD_y thermosets.

Materials	Reprocessing conditions	Aspect	Materials	Reprocessing conditions	Aspect
ECMO/ DTBA ₁₀₀	170 °C 10 min 2 Tons				
ECMO/ DTBA ₇₀ DTDA ₃₀	150 °C 15 min 1 Ton		ECMO/ DTBA ₇₀ 4-AFD ₃₀	150 °C 10 min 1 Ton	
ECMO/ DTBA ₅₀ DTDA ₅₀	150 °C 10 min 1 Ton		ECMO/ DTBA ₅₀ 4-AFD ₅₀	150 °C 10 min 0.5 Tons	
ECMO/ DTBA ₃₀ DTDA ₇₀	150 °C 10 minutes 1 Ton		ECMO/ DTBA ₃₀ 4-AFD ₇₀	150 °C 10 min 0.5 Tons	
ECMO/ DTDA ₁₀₀	170 °C 10 minutes 1 Ton		ECMO/ 4-AFD ₁₀₀	150 °C 10 min 0.3 Tons	

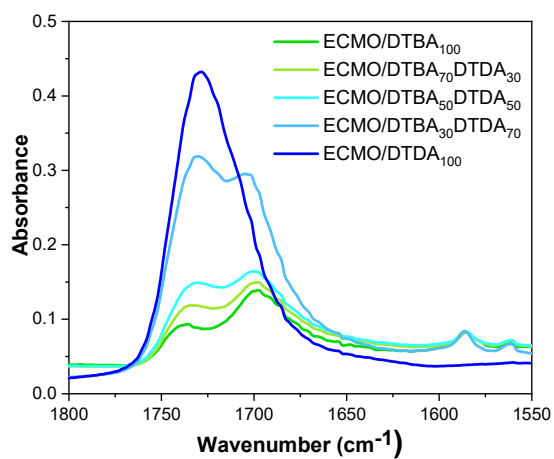


Figure S2. - FT-IR zoom of the ECMO/DTBA_xDTDA_y blends in the region from 1800 to 1150 cm⁻¹.

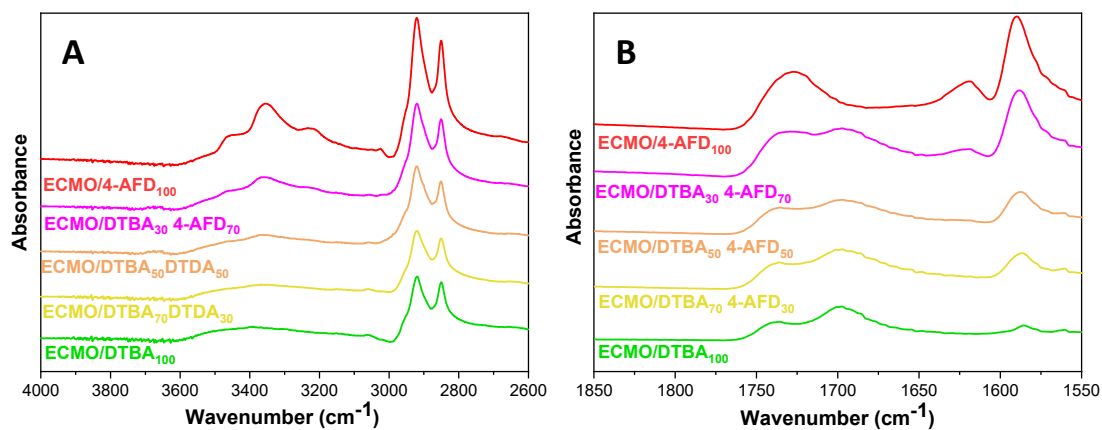


Figure S3. Evolution of FT-IR spectra of the uncured ECMO/DTBA_x4-AFD_y blends: (A) zoom in the region of 4000-2600 cm⁻¹ and (B) 1850-1550 cm⁻¹.

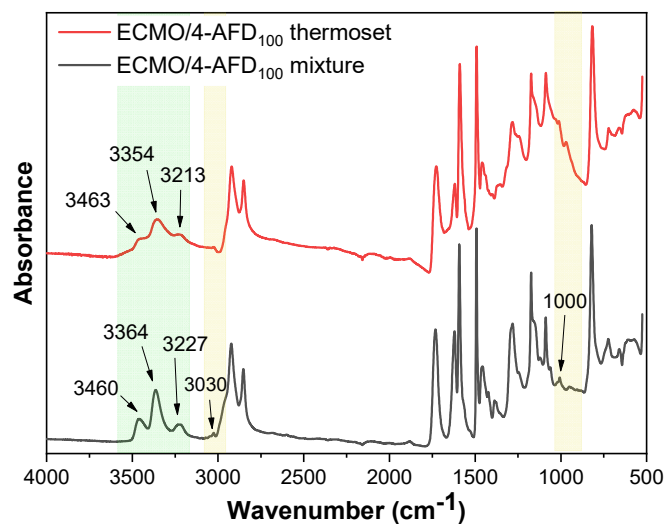


Figure S4. - FT-IR evolution of the reactive groups of the ECMO/4-AFD₁₀₀ in unreacted mixture and after the curing protocol.

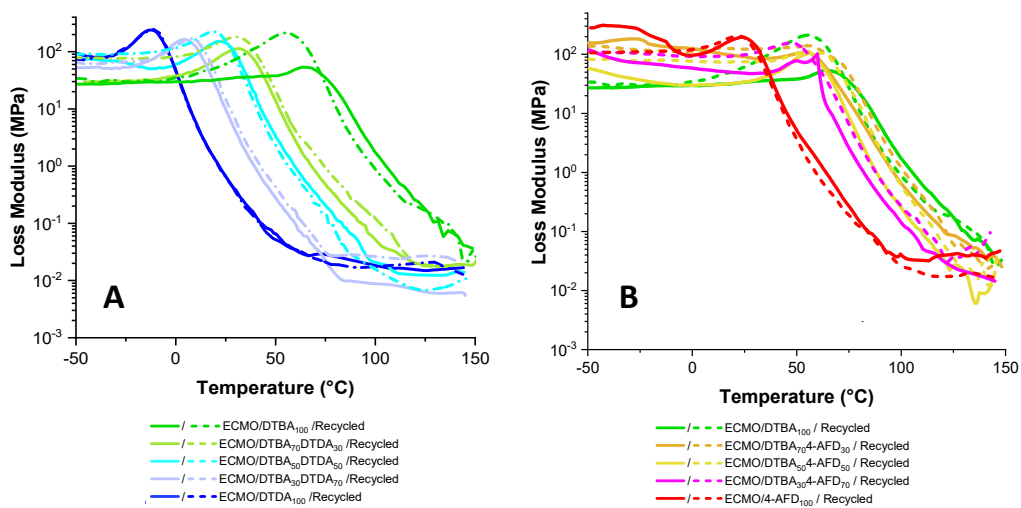


Figure S5. – Loss Modulus vs. temperature for the virgin and recycled (A) ECMO/DTBA_xDTDA_y and (B) ECMO/DTBA_x4-AFD_y thermosetting resins.

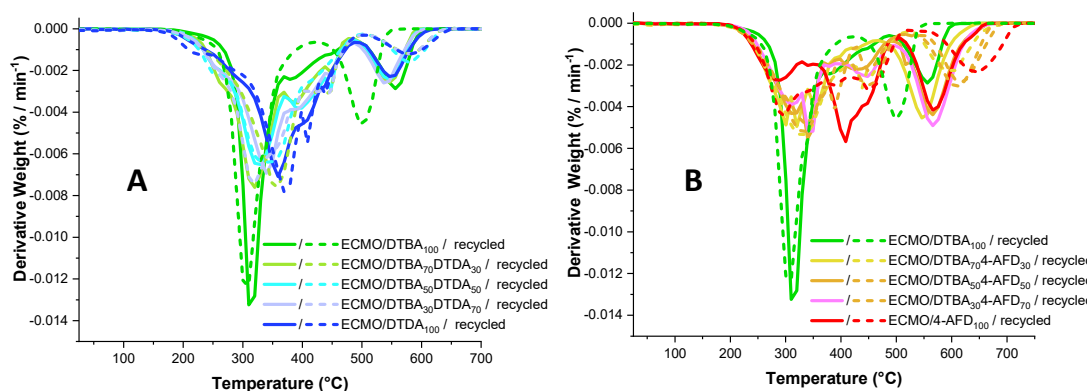


Figure S6. - DTG for the neat ECMO/DTBA_xDTDA_y and combination of the diacids crosslinkers **(A)** and neat ECMO/DTBA_x4-AFD_y and mixture of diacid/diamine blends **(B)**.

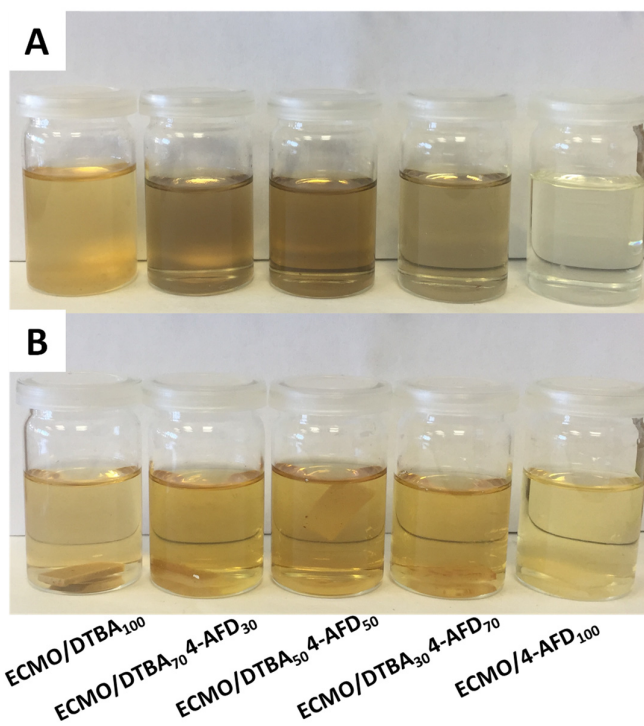


Figure S7. **(A)** Chemical recycling in DMF solution of dithiothreitol for ECMO/DTBA_xDTDA_x after 24 hours at 50 °C and **(B)** solvent resistance in 1N NaOH solution after 3 days at room temperature.

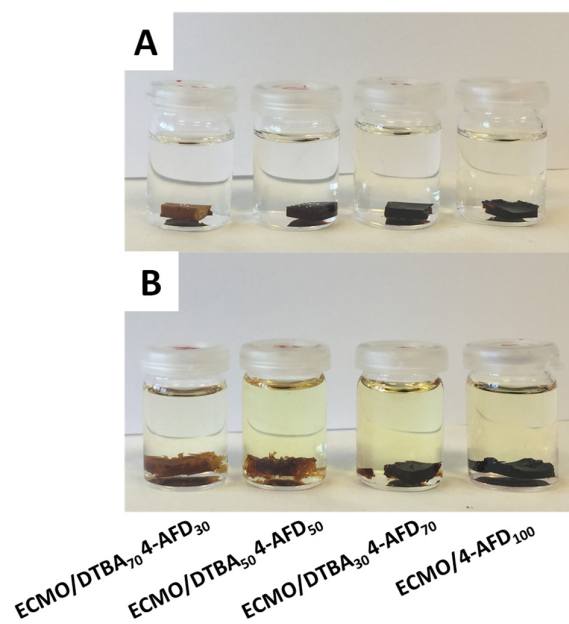


Figure S8. – Solvent resistance tests in (A) ethanol and (B) acetone after 72 hours at room temperature for the ECMO/DTBA_x-4-AFD_y resins.

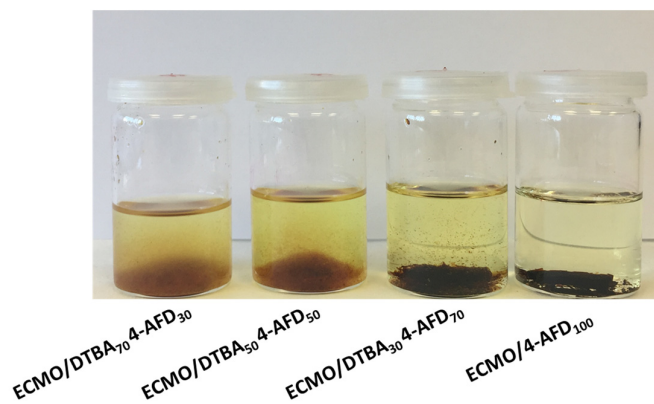


Figure S9. Solvent test in THF for ECMO/DTBA_x-4-AFD_y resins after 72 hours at room temperature.