Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Separation of Saturated Fatty Acids and Fatty Acid Methyl Esters with Epoxy Nanofiltration Membranes

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Table of Contents

Permeation of fatty acids through an epoxy membrane in a diffusion apparatus.

Fig S1. Diffusion apparatus used to monitor the flux of FAs and FAMEs through the epoxy membrane.

Table S1. Initial screening of the permeation of model fatty acids through epoxy membranes.

Molecules	Membrane	Relative Flux	Normalized Flux (mol/cm^2*h)[a]
Butyric Acid		5.84	2.83×10^{-6}
Undecylenic Acid	A-1	1.75	8.49×10^{-7}
Stearic Acid		1	4.85×10^{-7}
Butyric Acid		7.02	9.90×10^{-7}
Undecylenic Acid	A-2	3.01	4.24×10^{-7}
Stearic Acid		1.00	1.41×10^{-7}
Butyric Acid		21.4	4.24×10^{-7}
Undecylenic Acid	A-3	4.29	8.49×10^{-8}
Stearic Acid		1.00	1.98×10^{-8}

[a]All flux values carry a ± 4.24% relative error.

Table S2. Permeation of model fatty acids through epoxy membranes fabricated with epoxides 1 and 3.

Molecule	Membrane	Relative Flux	Normalized Flux (mol/cm^2*h)[a]
Butyric acid		7.97	1.41 x 10^{-6}
Undecylenic acid	A-$1^3 3^1$	3.20	5.66 x 10^{-7}
Stearic acid		1.00	1.77 x 10^{-7}
Butyric acid		16.6	1.41 x 10^{-6}
Undecylenic acid	A-$1^1 3^1$	4.99	4.24 x 10^{-7}
Stearic acid		1.00	8.49 x 10^{-8}
Butyric acid		22.5	8.49 x 10^{-7}
Undecylenic acid	A-$1^1 3^3$	7.51	2.83 x 10^{-7}
Stearic acid		1.00	3.77 x 10^{-8}

[a]All flux values carry a ± 4.24% relative error.

Table S3. Permeation of model fatty acids through epoxy membranes fabricated with epoxides 2 and 3.

Molecule	Membrane	Relative Flux	Normalized Flux (mol/cm^2*h)[a]
Butyric acid		30.0	8.49 x 10^{-7}
Undecylenic acid	A-$2^3 3^1$	4.98	1.41 x 10^{-7}
Stearic acid		1.00	2.83 x 10^{-8}
Butyric acid		20.0	8.49 x 10^{-7}
Undecylenic acid	A-$2^1 3^1$	3.33	1.41 x 10^{-7}
Stearic acid		1.00	4.24 x 10^{-8}
Butyric acid		60.2	8.49 x 10^{-7}
Undecylenic acid	A-$2^1 3^3$	8.01	1.13 x 10^{-7}
Stearic acid		1.00	1.41 x 10^{-8}

[a]All flux values carry a ± 4.24% relative error.

Table S4. Permeation of model fatty acids through epoxy membranes fabricated with epoxides 1 and 2.

Molecule	Membrane	Relative Flux	Normalized Flux (mol/cm^2*h)[a]
Butyric acid	A-$1^1 2^3$	6.67	2.83 x 10^{-6}
Undecylenic acid		3.00	1.27 x 10^{-6}
Stearic acid		1.00	4.24 x 10^{-7}
Butyric acid	A-$1^1 2^1$	4.99	4.24 x 10^{-6}
Undecylenic acid		1.67	1.41 x 10^{-6}
Stearic acid		1.00	8.49 x 10^{-7}
Butyric acid	A-$1^3 2^1$	6.67	3.77 x 10^{-6}
Undecylenic acid		3.00	1.70 x 10^{-6}
Stearic acid		1.00	5.66 x 10^{-7}

[a]All flux values carry a ± 4.24% relative error.

Permeation of fatty acid methyl esters (FAMEs) through a membrane in a diffusion apparatus.

Table S5. Permeation of saturated FAMEs through membrane A-$2^1 3^3$

Molecule	Relative Flux	Normalized Flux (mol/cm^2*h)[a]
Methyl butyrate (C_4)	100	9.90 x 10^{-8}
Methyl hexanoate (C_6)	57.1	5.66 x 10^{-8}
Methyl octanoate (C_8)	28.6	2.83 x 10^{-8}
Methyl decanoate (C_{10})	14.3	1.41 x 10^{-8}
Methyl laurate (C_{12})	8.58	8.49 x 10^{-9}
Methyl myristate (C_{14})	4.28	4.24 x 10^{-9}
Methyl palmiate (C_{16})	2.86	2.83 x 10^{-9}
Methyl stearate (C_{18})	1.00	9.90 x 10^{-10}

[a]All flux values carry a ± 4.24% relative error.

Table S6. Permeation of saturated FAMEs through membrane A-1[1]3[3]

Molecule	Relative Flux	Normalized Flux (mol/cm^2*h)[a]
Methyl butyrate (C_4)	49.8	1.41 x 10^{-7}
Methyl hexanoate (C_6)	28.3	8.49 x 10^{-8}
Methyl octanoate (C_8)	18.9	5.66 x 10^{-8}
Methyl decanoate (C_{10})	10.0	2.83 x 10^{-8}
Methyl laurate (C_{12})	4.70	1.41 x 10^{-8}
Methyl myristate (C_{14})	3.50	9.90 x 10^{-9}
Methyl palmiate (C_{16})	1.89	5.66 x 10^{-9}
Methyl stearate (C_{18})	1.00	2.83 x 10^{-9}

[a]All flux values carry a ± 4.24% relative error.

^{1}H NMR and ^{13}C NMR spectrums of methyl undecylenate.

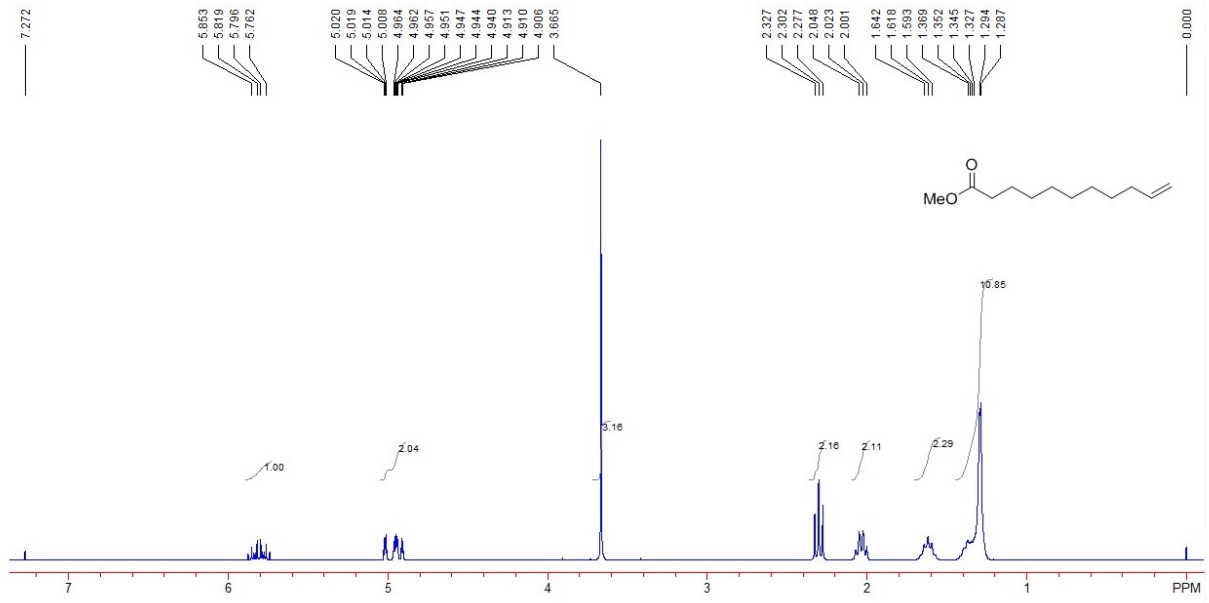

Figure S2. ^{1}H NMR spectrum of methyl undecylenate in $CDCl_3$.

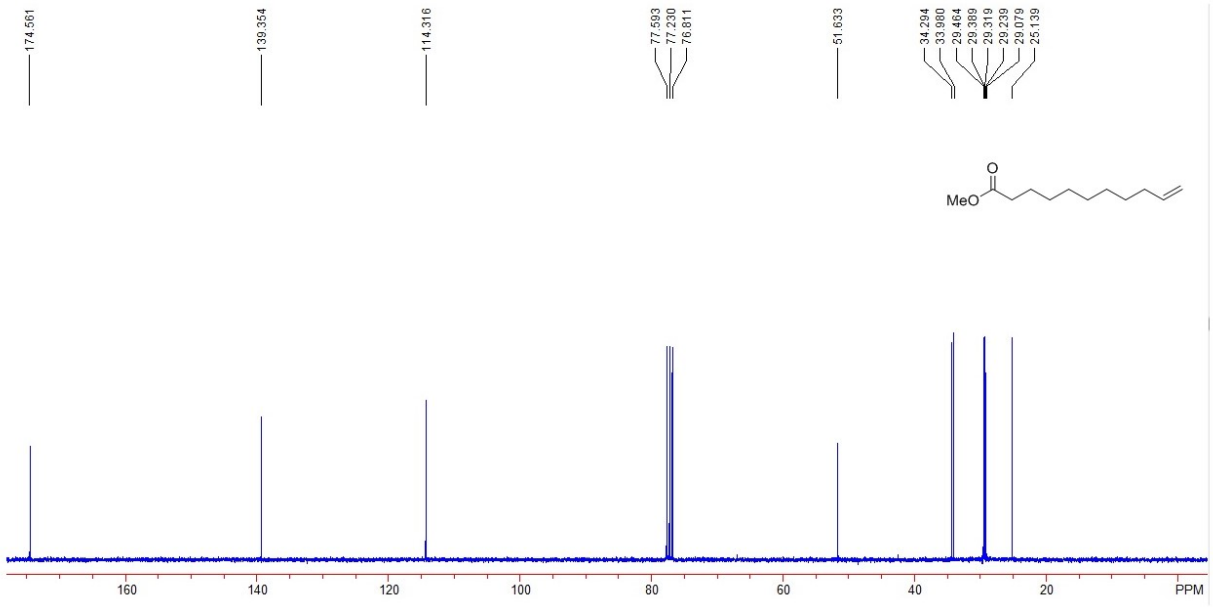

Figure S3. ^{13}C NMR spectrum of methyl undecylenate in $CDCl_3$.

AFM images of spin-coated epoxy membrane A-2.

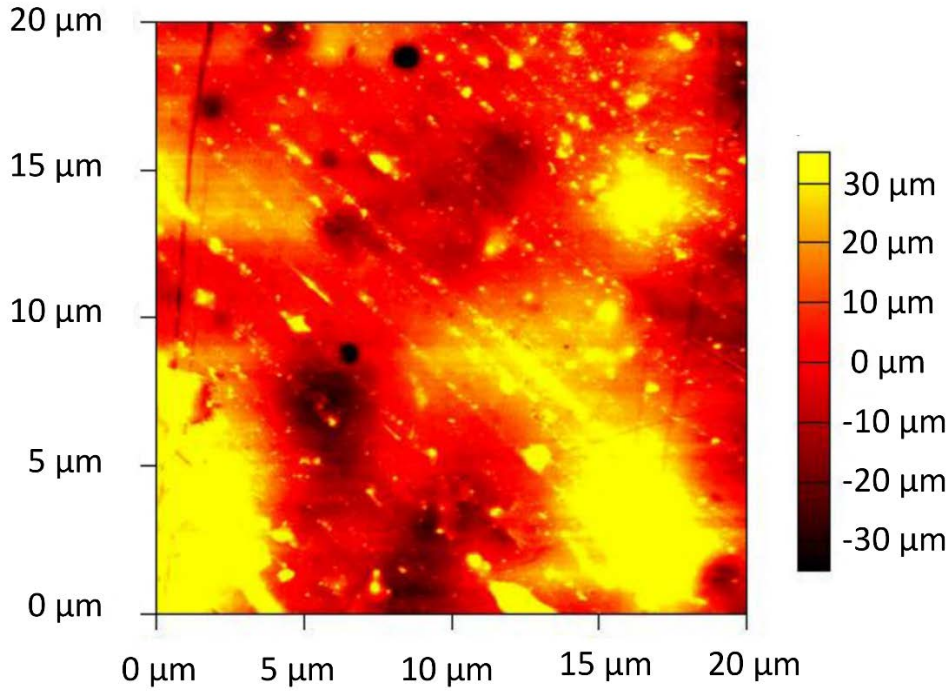

Figure S4. 2D AFM image showing the changes in height on the surface of a spin-coated epoxy membrane A-2.

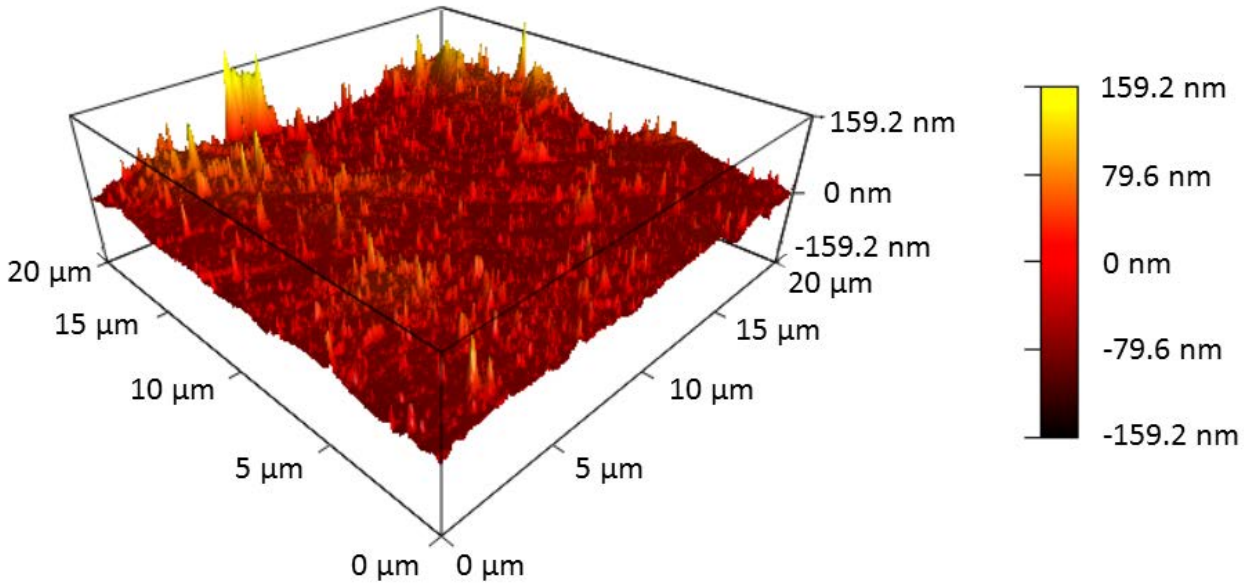

Figure S5. 3D AFM image showing the changes in height on the surface of a spin-coated epoxy membrane.

Permeation of methyl undecylenate and methyl stearate through membrane A-2 in a pressure apparatus.

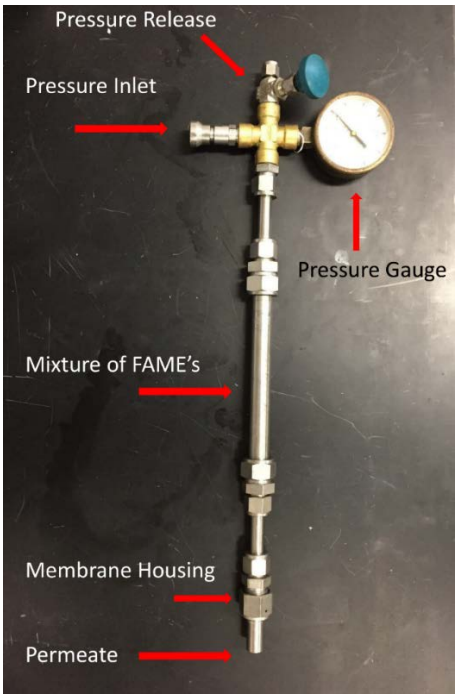

Figure S6. Dead end-filtration apparatus for high pressure experiments

Table S7. Composition of FAMEs collected in the pressure experiment with membrane A-2.

	Mass of FAMEs (mg)	Methyl Undecylenate (mol%)	Methyl Stearate (mol %)
Initial[a]	1,860	49.9	50.1
Fraction 1	38.0	67.9	32.1
Fraction 2	42.3	68.5	31.5
Fraction 3	44.3	67.7	32.3
Fraction 4	85.1	70.0	30.0
Fraction 5[b]	60.7	62.2	37.8
Total Permeate	270	67.4	32.6
Retention	1,480	45.5	54.5

[a]Initial composition was determined by removing a 1 mL sample of the initial mixture and analyzing via ^{1}H NMR spectroscopy.
[b]Fraction 5 is the sample that was on the permeate side of the dead-end filtration and did not go into the vial. This sample was collected by washing the end of the metal apparatus with DCM and removing DCM to obtain the FAMEs.

Table S8. Composition of FAME's collected in the pressure experiment with membrane A-2[1]3[3].

	Mass of FAME's and FAEE (mg)	Methyl Hexanoate (mol%)	Methyl Undecylenate (mol%)	Ethyl Stearate[d] (mol%)
Initial[a]	2,380	32.8	33.1	34.1
Fraction 1	12.0	17.7[c]	62.1	20.2
Fraction 2[b]	53.6	30.6[c]	52.5	16.8
Retention	2,110	32.3	32.2	35.4

[a]Initial composition was determined by removing a 1 mL sample of the initial mixture and analyzing via ^{1}H NMR spectroscopy.
[b]Fraction 2 is the sample that was on the permeate side of the dead-end filtration and did not go into the vial. This sample was collected by washing the end of the metal apparatus with DCM and removing DCM to obtain the FAMEs.
[c]Due to the low boiling point of methyl hexanoate, it had evaporated from the permeate side before analysis could be completed.
[d]Ethyl stearate was used in this experiment because it has a unique peak in the ^{1}H NMR spectrum that so it can be distinguished from the other two FAMEs being used.

Permeation of a multicomponent mixture of FAMEs through epoxy membrane A-2 in a pressure apparatus.

Table S9. Composition of FAMEs collected in the pressure experiment with membrane A-2.

	Mass of FAMEs (mg)	Methyl Decanoate (mol%)	Methyl Laurate (mol %)	Methyl Myristate (mol%)	Methyl Palmitate (mol%)	Methyl Stearate (mol%)
Initial	4,510	23.2	20.6	19.7	19.6	16.8
Fraction 1	46.1	31.0	21.5	18.9	15.5	13.0
Fraction 2	10.2	31.8	21.6	17.6	16.3	12.7
Fraction 3	53.7	31.1	23.2	18.5	15.2	12.0
Fraction 4	91.8	30.9	24.1	18.5	15.4	11.0
Fraction 5[b]	85.5	27.7	24.9	19.0	16.5	11.9
Total Permeate	287	30.3	23.4	18.6	15.8	11.9
Retention	3,920	22.1	22.0	19.7	20.1	16.1

[a] Initial composition was determined by removing a 1 mL sample of the initial mixture and analyzing via gas chromatography-mass spectrometry (GC-MS).

[b]Fraction 5 is the sample that was on the permeate side of the dead-end filtration and did not go into the vial. This sample was collected by washing the end of the metal apparatus with DCM and removing DCM to obtain the FAMEs.