

Efficient conversion of monosaccharides into 5-hydroxymethylfurfural using acidic deep eutectic solvents

Linh Ngoc To ^{1,2†}, Trinh Hao Nguyen ^{1,2†}, Thien Phuoc Nguyen ^{1,2}, Ha Bich Phan ^{1,2,3}, Linh Ho Thuy Nguyen ^{2,4}, Tan Le Hoang Doan ^{2,4}, Chinh Van Dang ³ and Phuong Hoang Tran ^{1,2,*}

¹ Department of Organic Chemistry, Faculty of Chemistry, University of Science, Ho Chi Minh City 700000, Vietnam.

² Vietnam National University, Ho Chi Minh City 700000, Vietnam.

³ Institute of Public Health, Ho Chi Minh City 700000, Vietnam.

⁴ Center for Innovative Materials and Architectures (INOMAR), Ho Chi Minh City 700000, Vietnam

† The authors contributed equally

*Correspondence: +84-903-706-762; e-mail: thphuong@hcmus.edu.vn

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Section 1: Experimental section

Chemical

Urea (>99%), iron (III)chloride (>99%), D-fructose (>99%), D-glucose (>99%), , tetrabutylammonium bromide (>99%), , D-chloroform (>99%), was purchased from Merck. Ethylene glycol (>99%), tetrahydrofuran (>99%) was collected from Xilong (China). Ethyl acetate (>99%), acetone (>99%), hexane (>99%), ethanol (>99%), methanol (>99%) was obtained from Chemsol (Vietnam). 5-Hydroxymethylfurfural (HMF) (>99%), 2,5-diformylfuran (DFF) (>99%), 2,5-Furandicarboxylic acid (FDCA) (>99%), furfural (Fur) (>99%), choline chloride (>99%), chromium (III) chloride hexahydrate (>99%), zinc chloride (>99%), fumaric acid (>99%), adipic acid (>99%), benzoic acid (>99%), malonic acid (>99%), tin (II) chloride dihydrate (>99%), and copper dichloride dihydrate (>99%) was obtained from Sigma-Aldrich. All chemical was used without further purification.

Equipment

Thermogravimetric analysis (TGA) with model TGA/DSC3 (Mettler, Toledo, Switzerland) was used to analyze and evaluate the thermal stability of DES. Samples were calcined from room temperature to 800 °C with a scanning speed of 10 Kpm, in N₂. Fourier-transform infrared spectroscopy (FTIR) were recorded on a Bruker's VERTEX 70 series FT-IR spectrometers with a measuring range of 600– 4000 cm⁻¹.

The HMF was quantified by Agilent Technologies 1260 Infinity HPLC with a DAD de-tector at wavelength 285 nm. The column Inert Sustain C18 (5 µm, 4.6 × 150 mm) was used to separate the components of the reaction mixture. The column temperature was obtained at 30 °C. A mixture of methanol and 2.5 mM sulfuric acid was used as eluent with a flow rate of 0.7 mL min⁻¹.

Section 2: Characterization of DESs

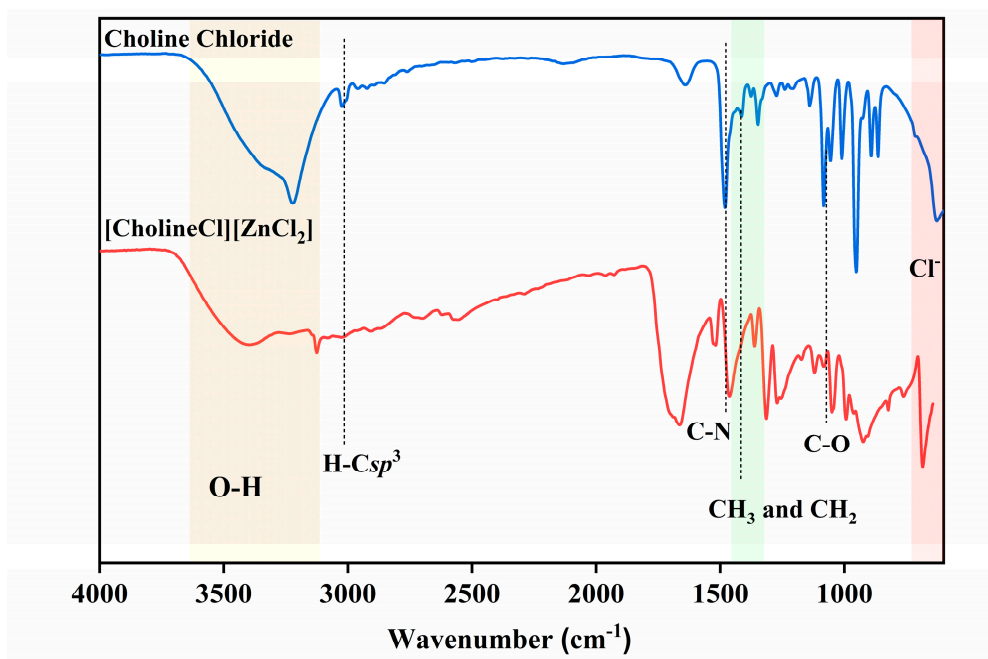


Figure S2.1: FTIR spectrum of [CholineCl][ZnCl₂]

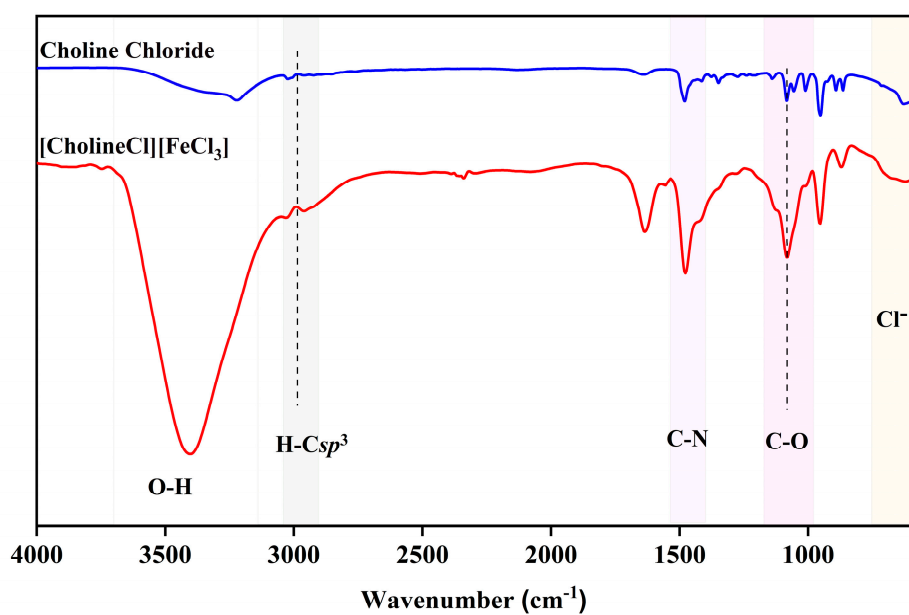


Figure S2.2: FTIR spectrum of [CholineCl][FeCl₃]

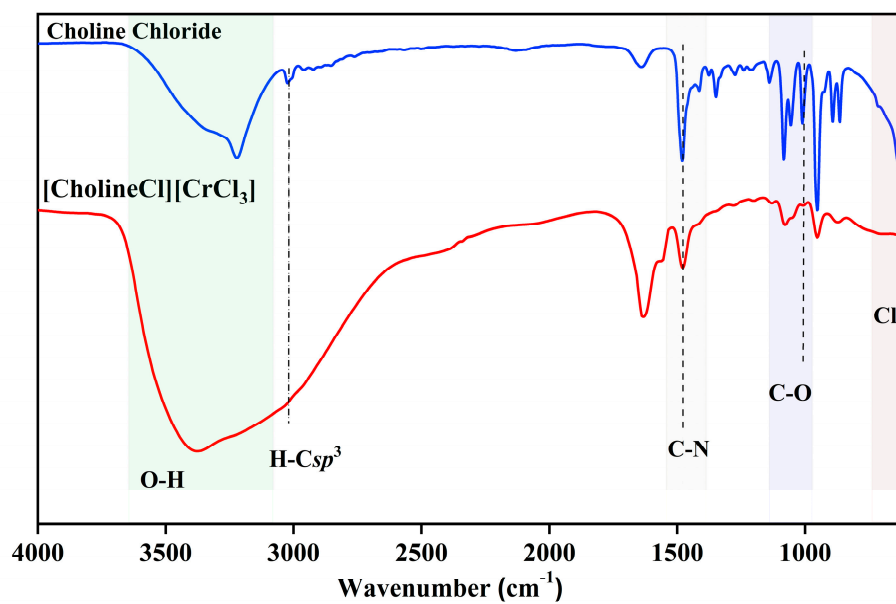


Figure S2.3: FTIR spectrum of [CholineCl][CrCl₃]

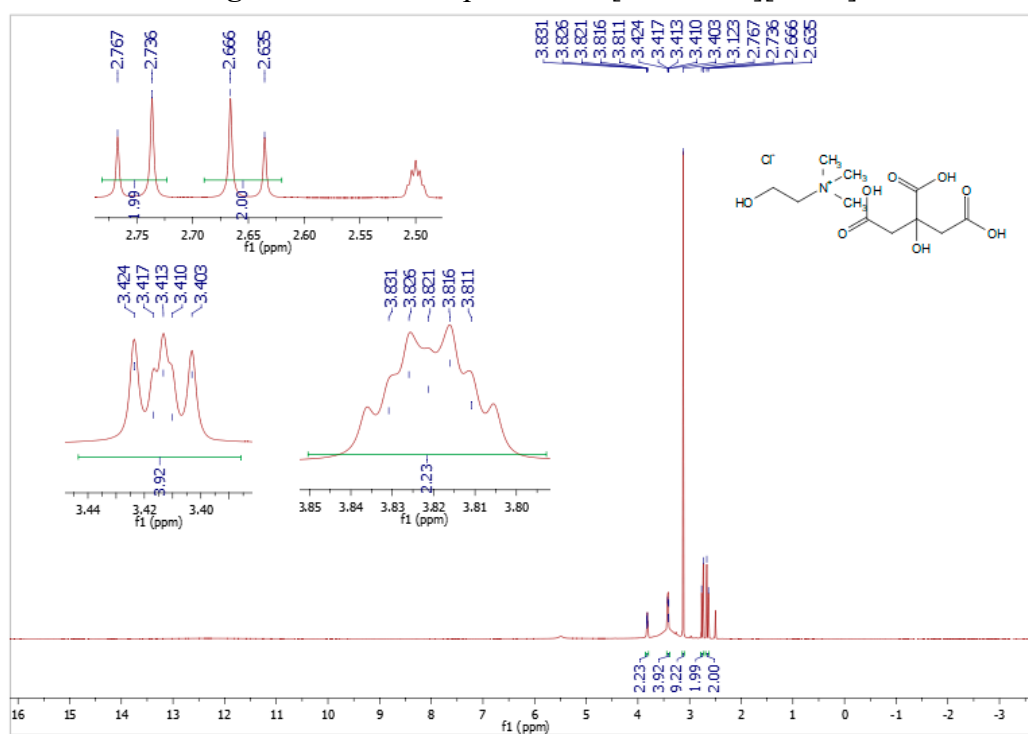


Figure S2.4: ¹H-NMR spectrum of [CholineCl][Citric acid]

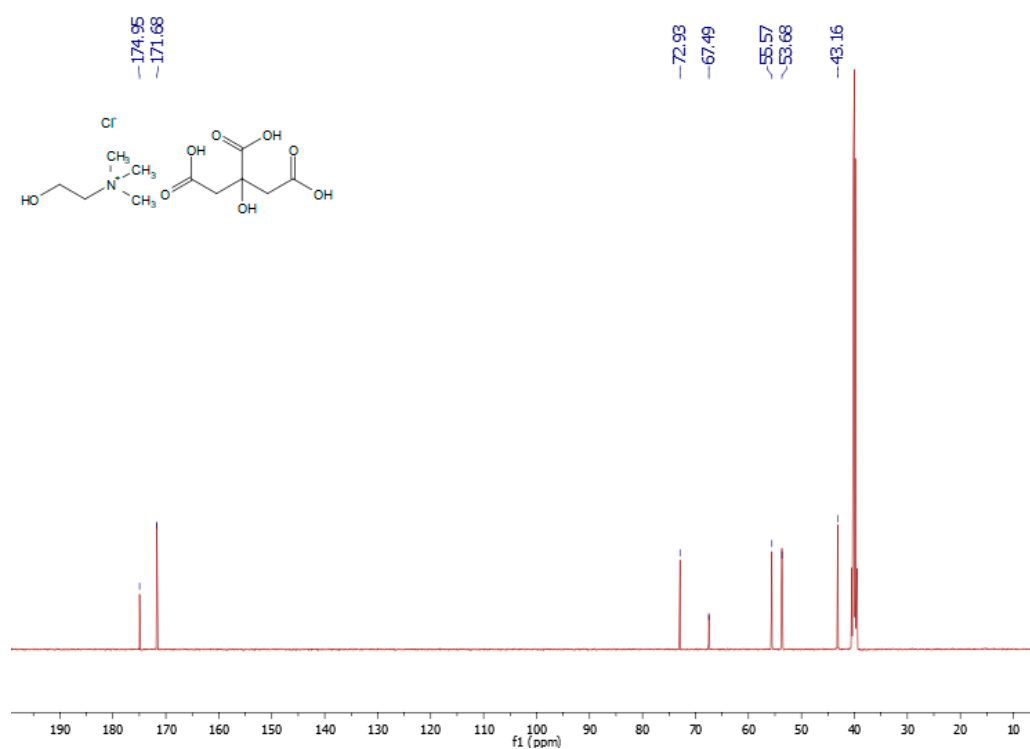


Figure S2.5: ^{13}C -NMR spectrum of [CholineCl][Citric acid]

Section 3: Characterization of HMF and calibration curve of HMF

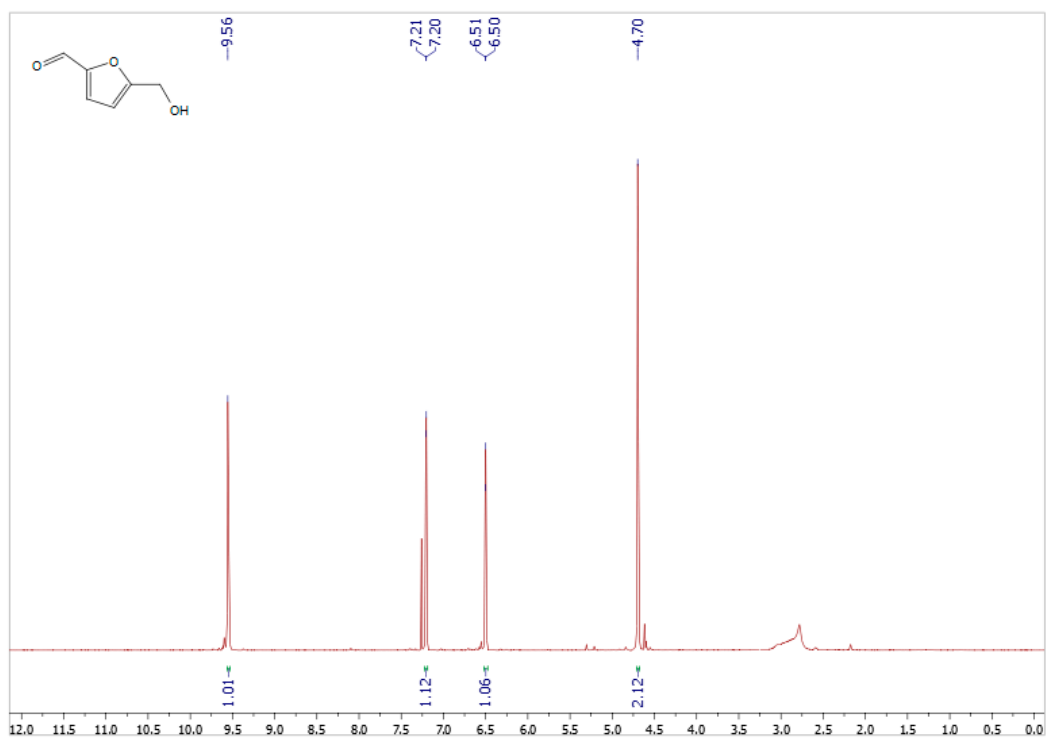


Figure S3.1: ^1H -NMR spectrum of HMF

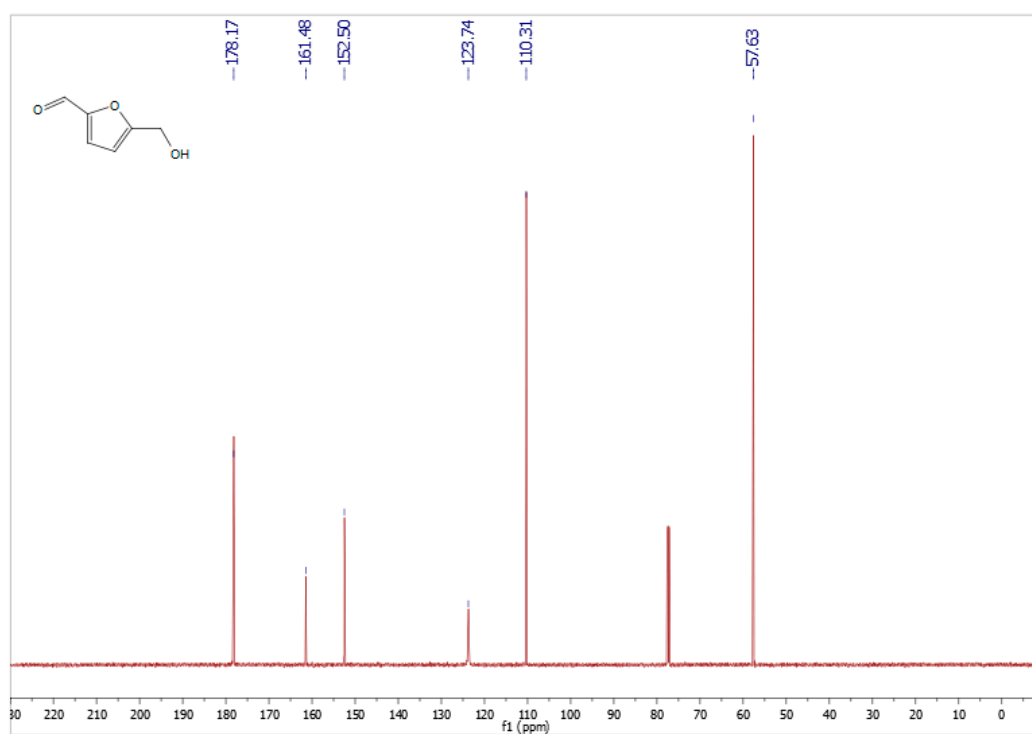


Figure S3.2: ^{13}C -NMR spectrum of HMF

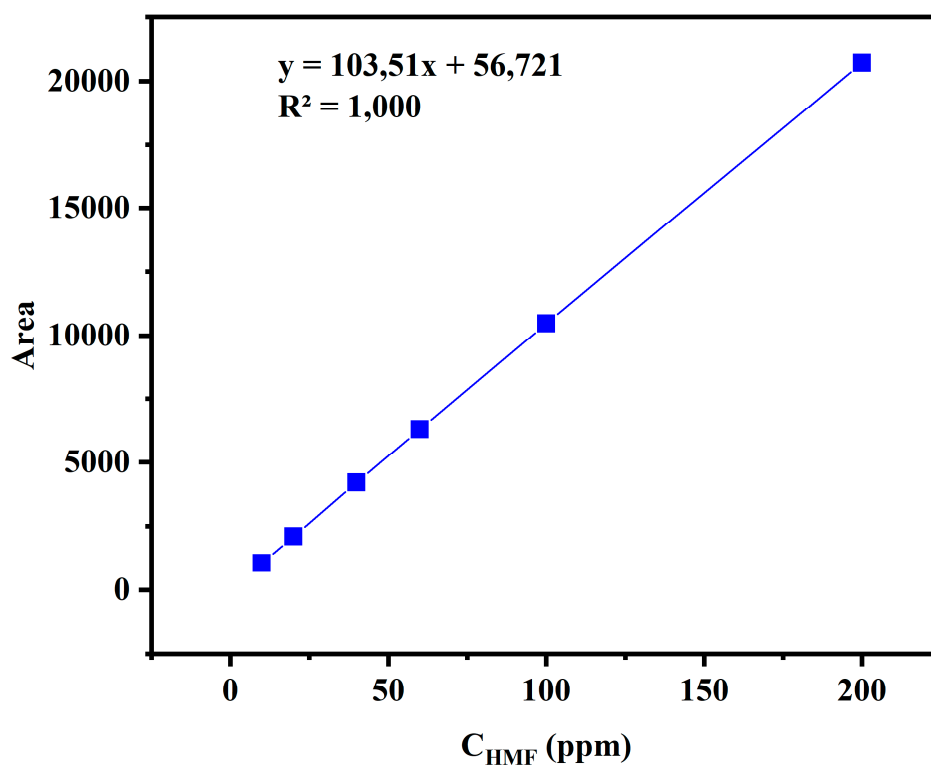
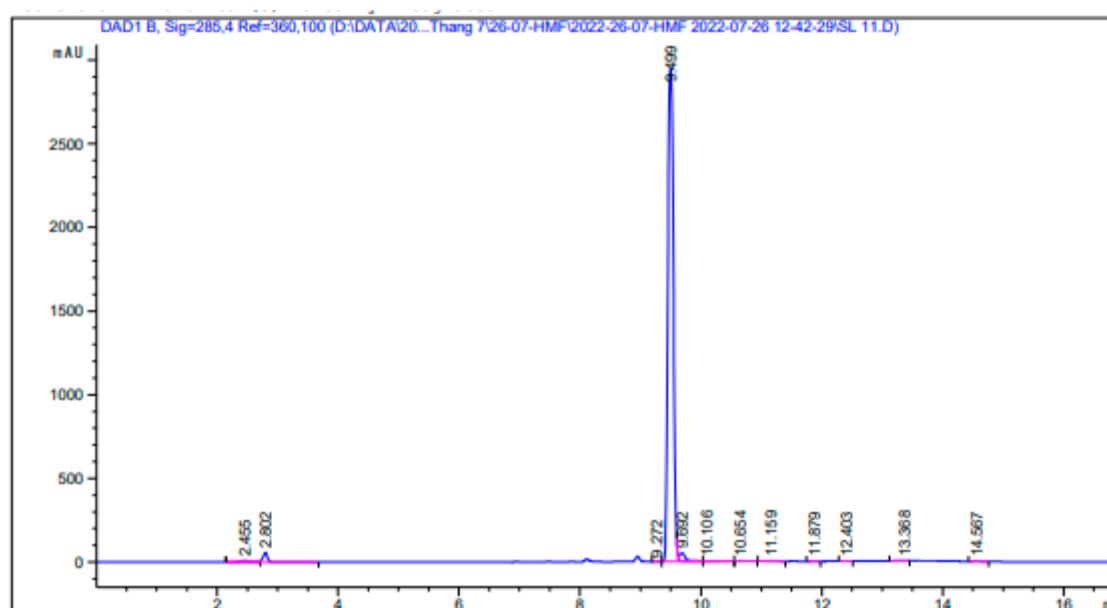


Figure S3.3: Calibration curve of HMF

Section 4: HPLC chromatography



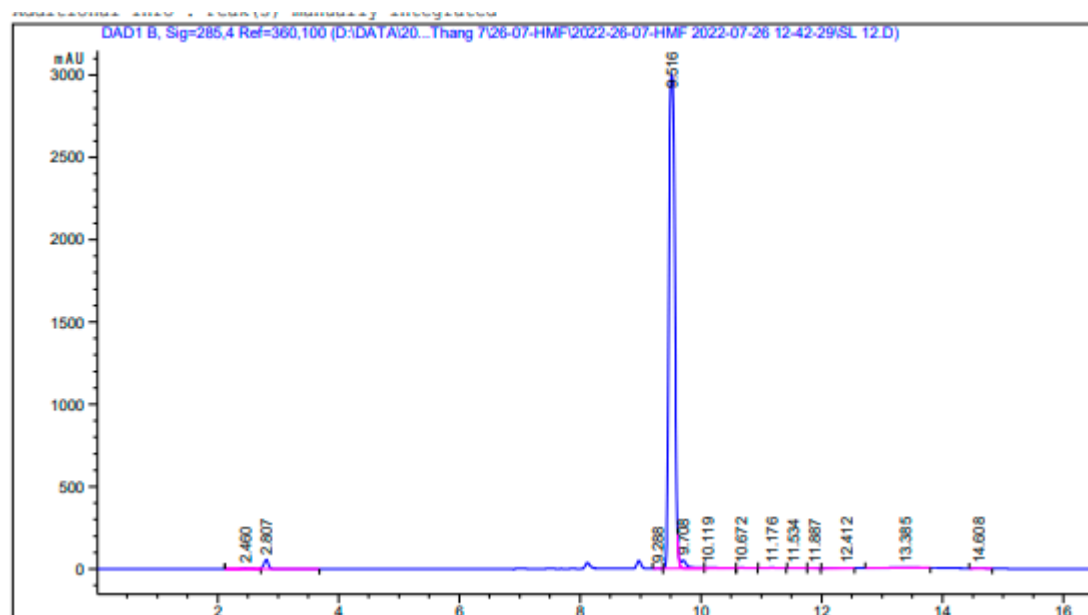
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8.900	-	-	-	-	-	Levulinic acid
9.499	BV R	1.87197e4	9.62812e-3	180.23518	-	HMF
10.654	BB	18.91986	2.74634e-2	5.19604e-1	-	DFF
11.159	BB	21.26656	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4.1: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 100 °C, 5 min.



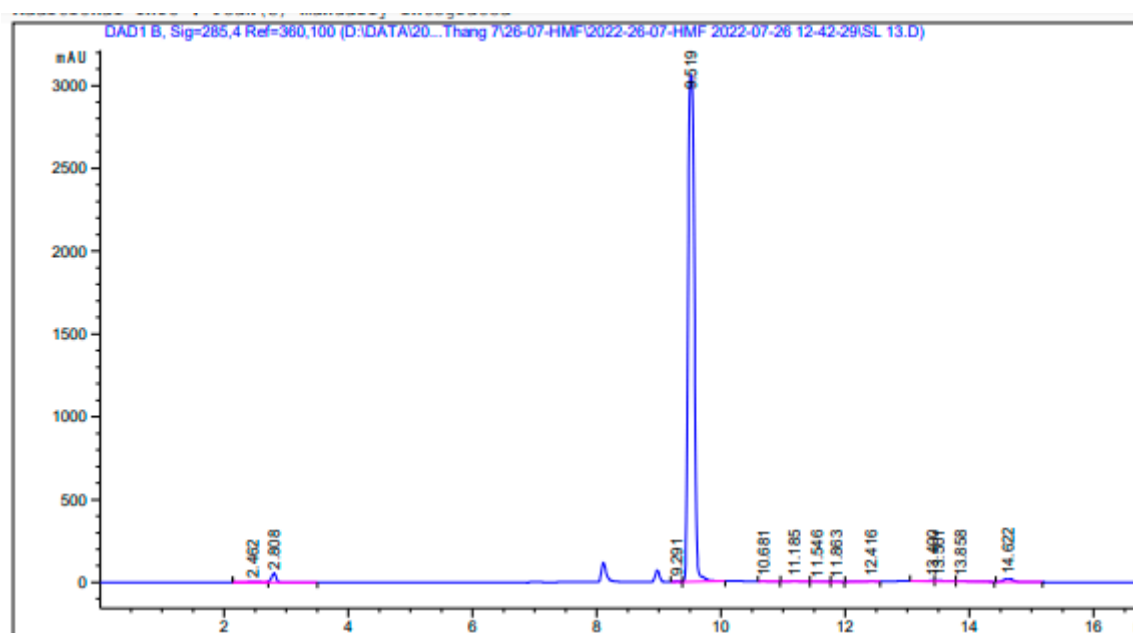
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RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.516	BV R	2.01682e4	9.62965e-3	194.21244	-	HMF
10.672	BB	17.61892	2.87232e-2	5.06072e-1	-	DFF
11.176	BB	26.74589	0.00000	0.00000	-	FDCA
11.534	BV	6.54524	0.00000	0.00000	-	Furfural

Figure S4. 2: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 100 °C, 10 min.



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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-		Levulinic acid
9.519	BB	2.10779e4	9.63050e-3	202.99041		HMF
10.681	BB	15.97031	3.06145e-2	4.88924e-1		DFF
11.185	BV	37.75508	0.00000	0.00000		FDCA
11.546	VV	21.10468	0.00000	0.00000		Furfural

Figure S4.3: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 100 °C, 20 min.

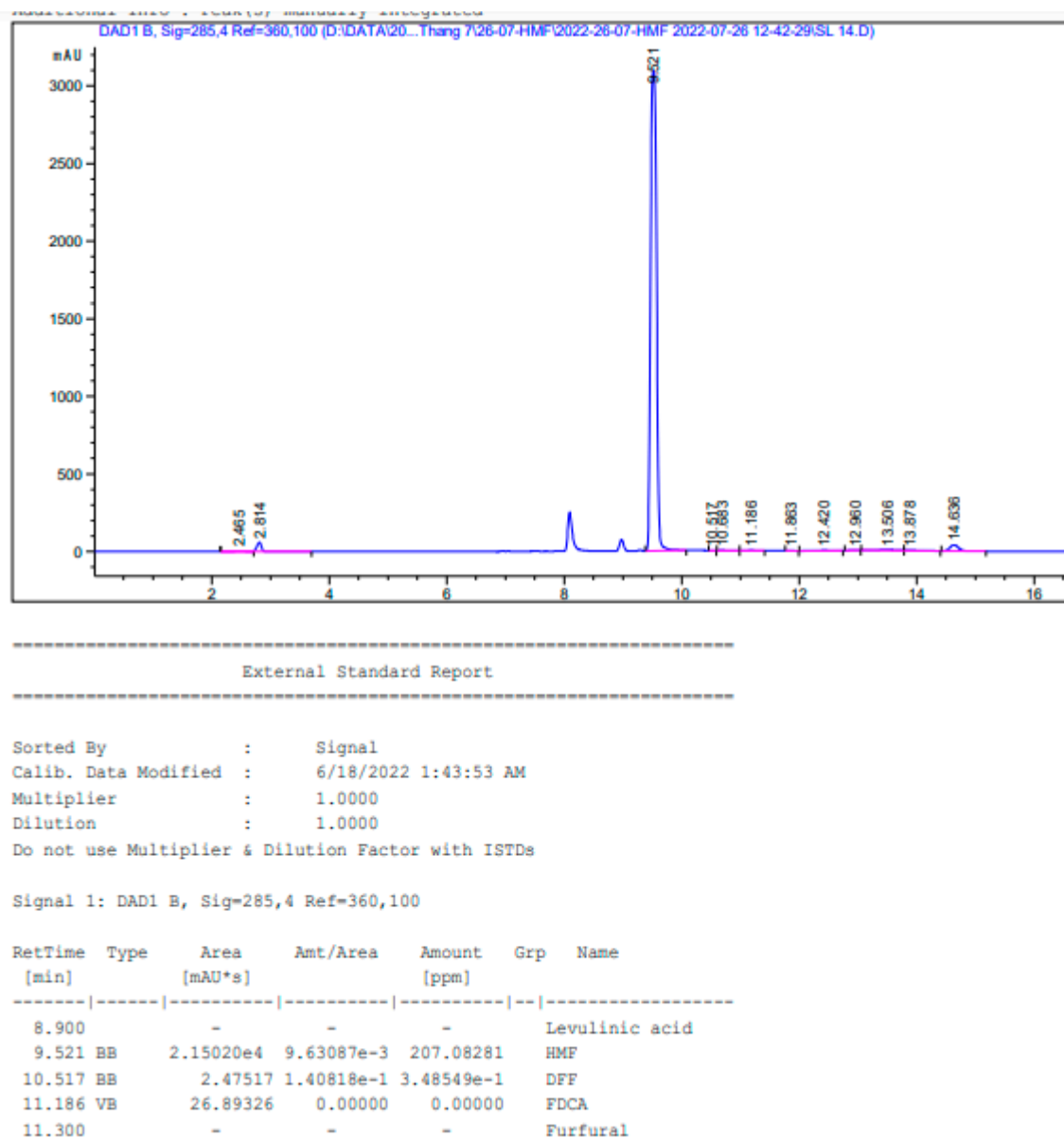
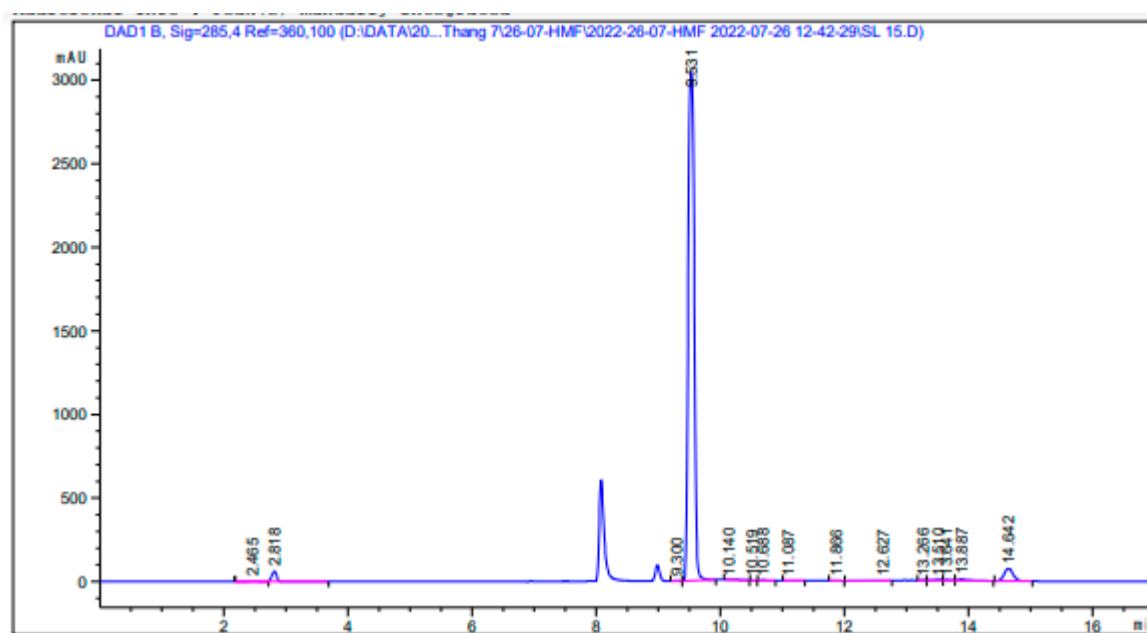


Figure S4. 4: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 100 °C, 30 min.



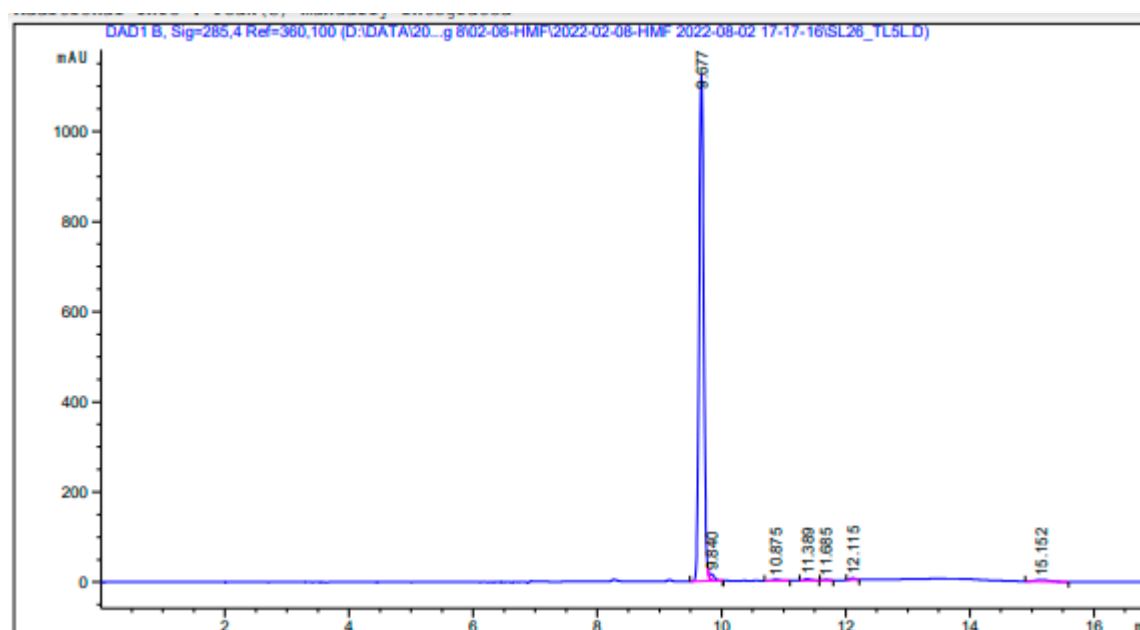
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.531	BB	2.02327e4	9.62971e-3	194.83475	-	HMF
10.519	BB	2.00498	1.71402e-1	3.43658e-1	-	DFF
11.087	BB	9.82065	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 5: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 100 °C, 60 min.



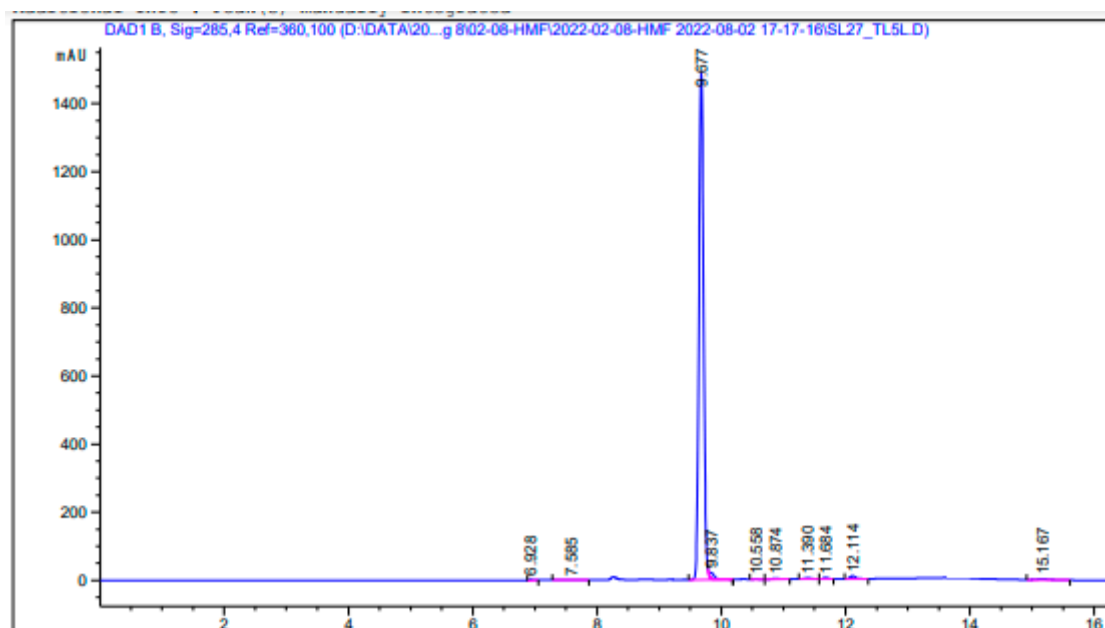
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.677	BV R	5727.15967	9.57982e-3	54.86517	-	HMF
10.201	-	-	-	-	-	DFF
10.875	BB	20.97607	0.00000	0.00000	-	FDCA
11.389	BB	21.08057	0.00000	0.00000	-	Furfural

Figure S4. 6: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 100 °C, 5 min.



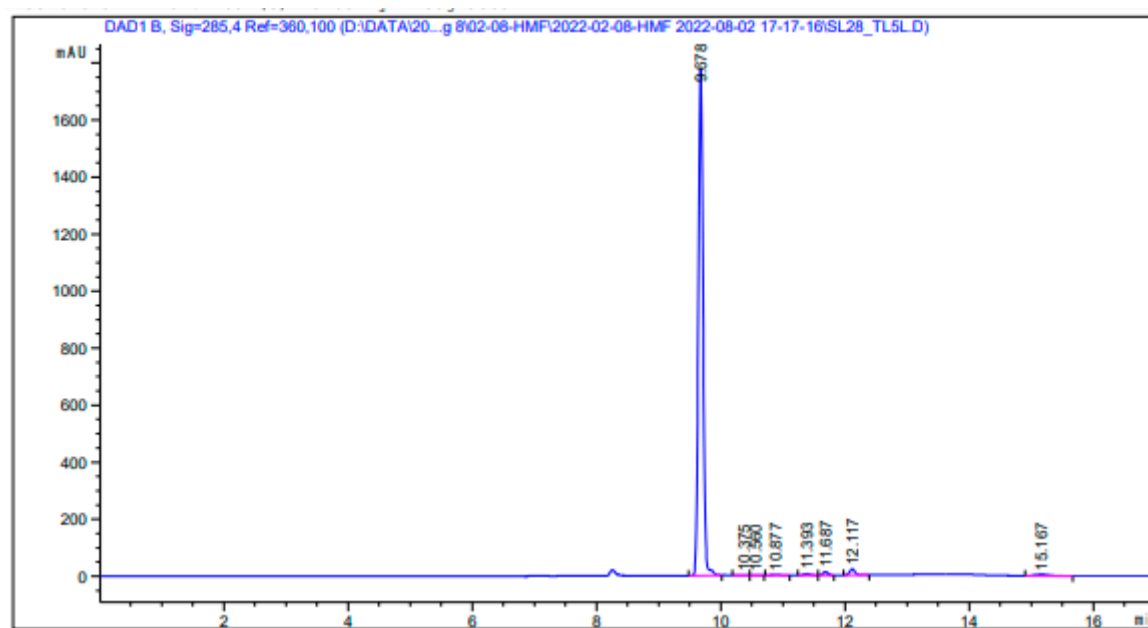
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.677	BV R	7649.29150	9.59731e-3	73.41261	-	HMF
10.201	-	-	-	-	-	DFF
10.874	BB	21.11240	0.00000	0.00000	-	FDCA
11.390	BV	25.65583	4.75866e-4	1.22087e-2	-	Furfural

Figure S4. 7: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 100 °C, 10 min.



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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.678	BV R	9262.65723	9.60638e-3	88.98063		HMF
10.375	BV	6.63925	5.90222e-2	3.91863e-1		DFF
10.877	BB	21.39795	0.00000	0.00000		FDCA
11.393	BV	31.51947	2.28775e-3	7.21087e-2		Furfural

Figure S4. 8: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 100 °C, 20 min.

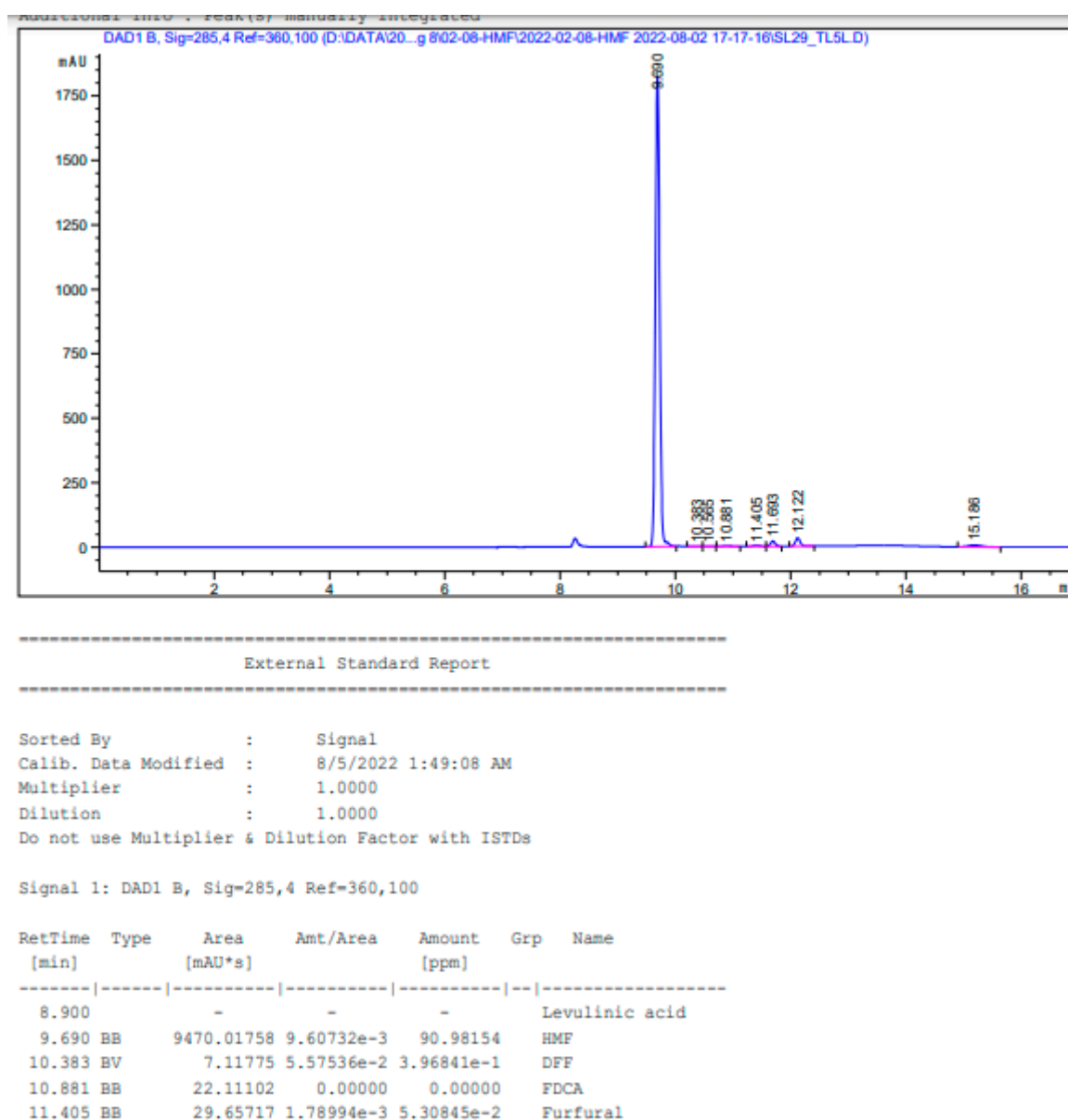
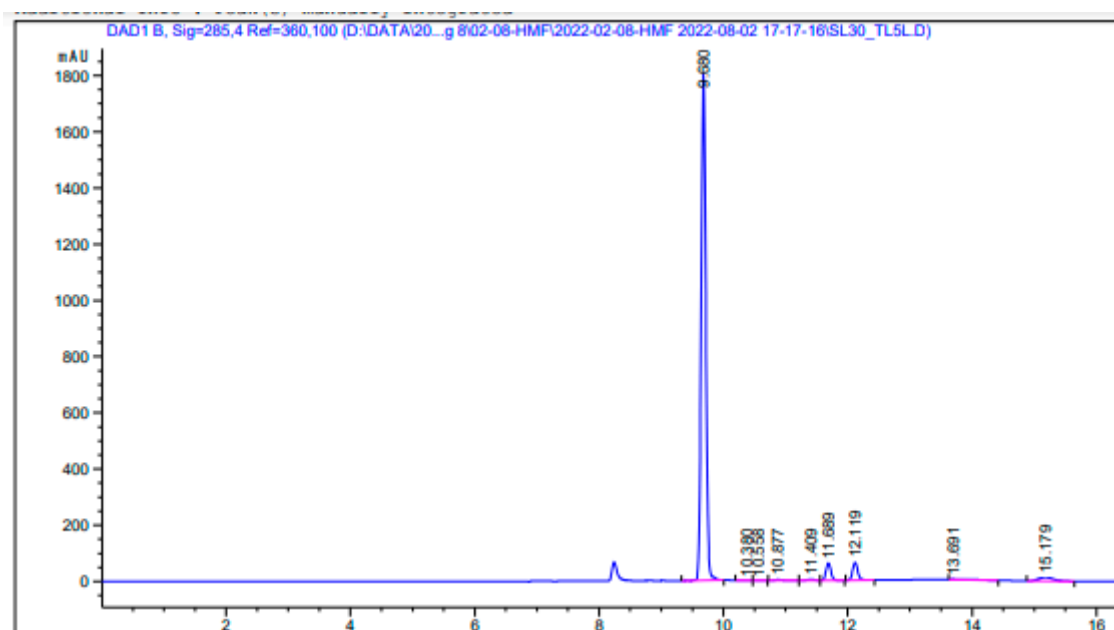


Figure S4. 9: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 2 (5 mmol), 100 °C, 30 min.



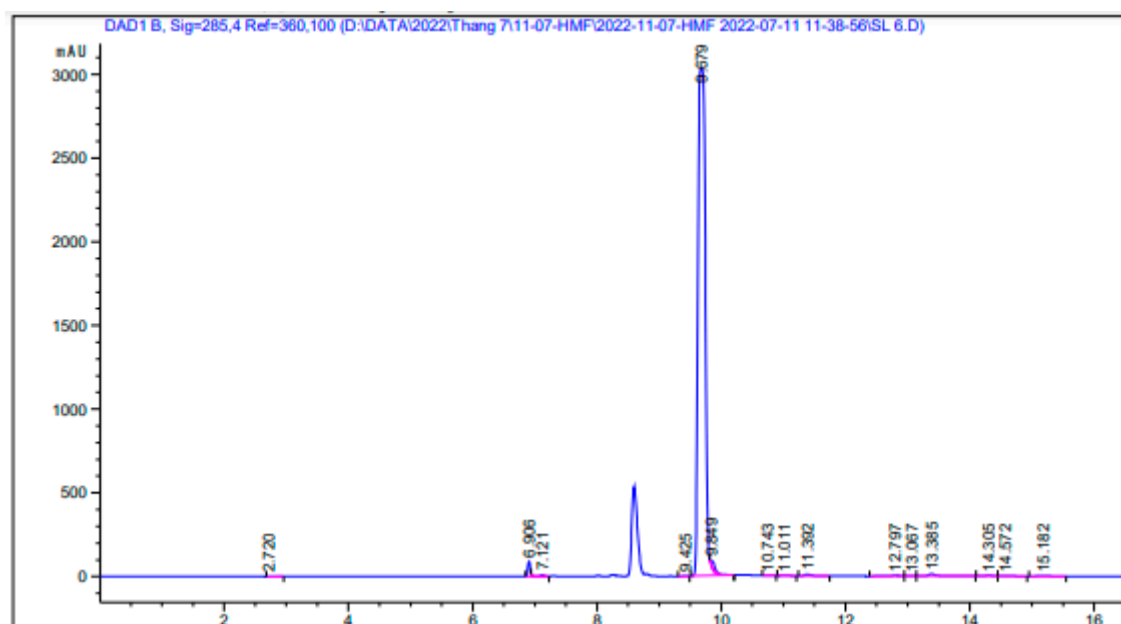
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.680	VB R	9406.10254	9.60704e-3	90.36479		HMF
10.380	BV	8.04894	5.05069e-2	4.06527e-1		DFF
10.877	BB	24.10202	0.00000	0.00000		FDCA
11.409	BV	25.91365	5.72768e-4	1.48425e-2		Furfural

Figure S4. 10: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 100 °C, 60 min.



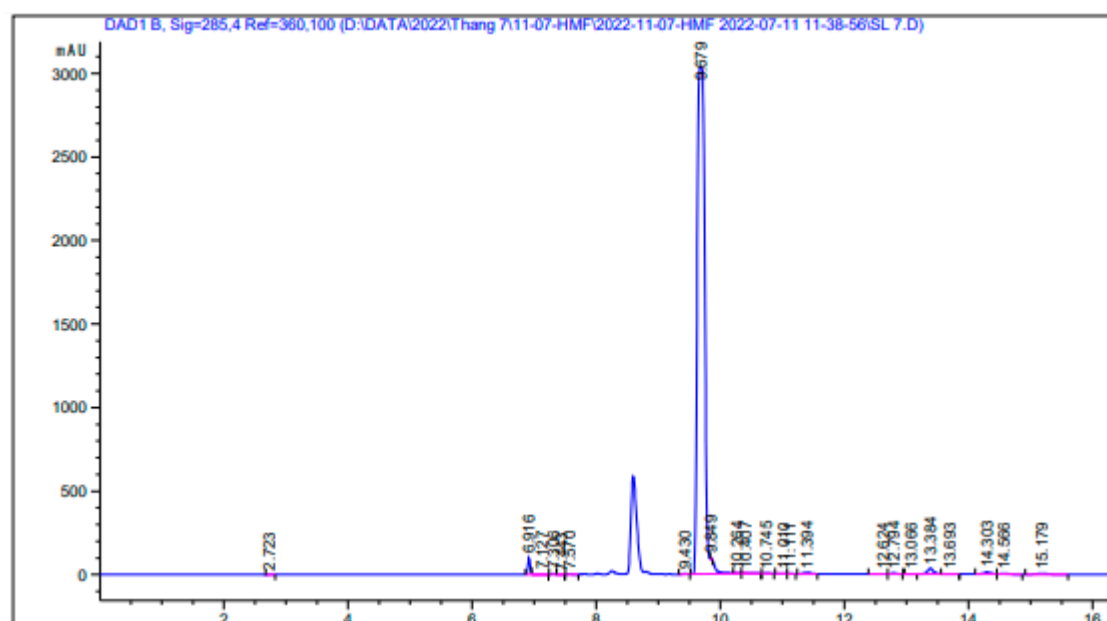
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.770	-	-	-	-	-	Levulinic acid
9.679	BV R	2.45316e4	1.06855e-2	262.13252	-	HMF
10.275	-	-	-	-	-	DFF
11.011	BB	14.14764	1.74360e-1	2.46678	-	FDCA
11.392	BB	63.87226	0.00000	0.00000	-	Furfural

Figure S4. 11: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 3 (5 mmol), 100 °C, 5 min.



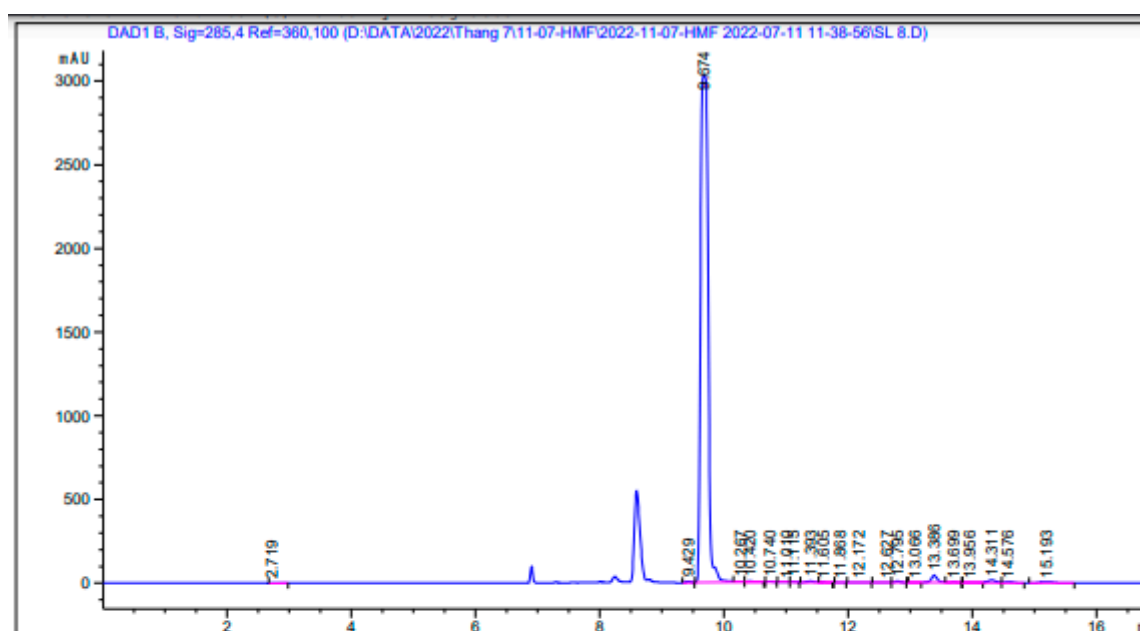
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.679	BV R	2.53973e4	9.63372e-3	244.67060	-	HMF
10.264	VV X	2.01953	1.70243e-1	3.43810e-1	-	DFF
11.111	VB	9.48687	0.00000	0.00000	-	FDCA
11.394	BB	57.81212	5.89325e-3	3.40701e-1	-	Furfural

Figure S4. 12: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 3 (5 mmol), 100 °C, 10 min.



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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.770	-	-	-	-		Levulinic acid
9.674	BV R	2.54529e4	1.06825e-2	271.89968		HMF
10.267	VV E	12.29513	2.64481e-1	3.25183		DFF
11.010	BV	10.09167	2.04753e-1	2.06630		FDCA
11.393	BV R	56.76549	0.00000	0.00000		Furfural

Figure S4. 13: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 3 (5 mmol), 100 °C, 20 min.

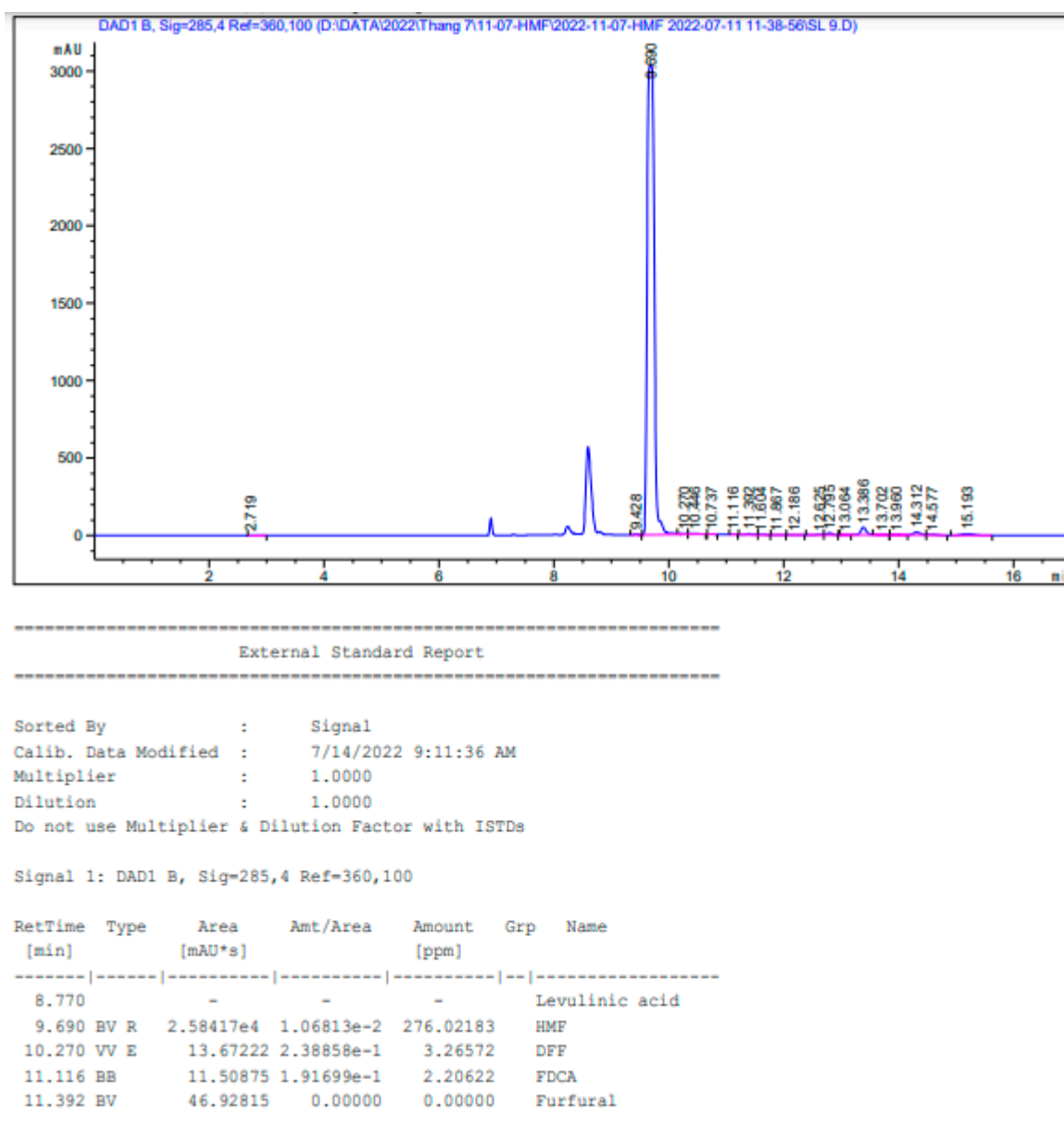
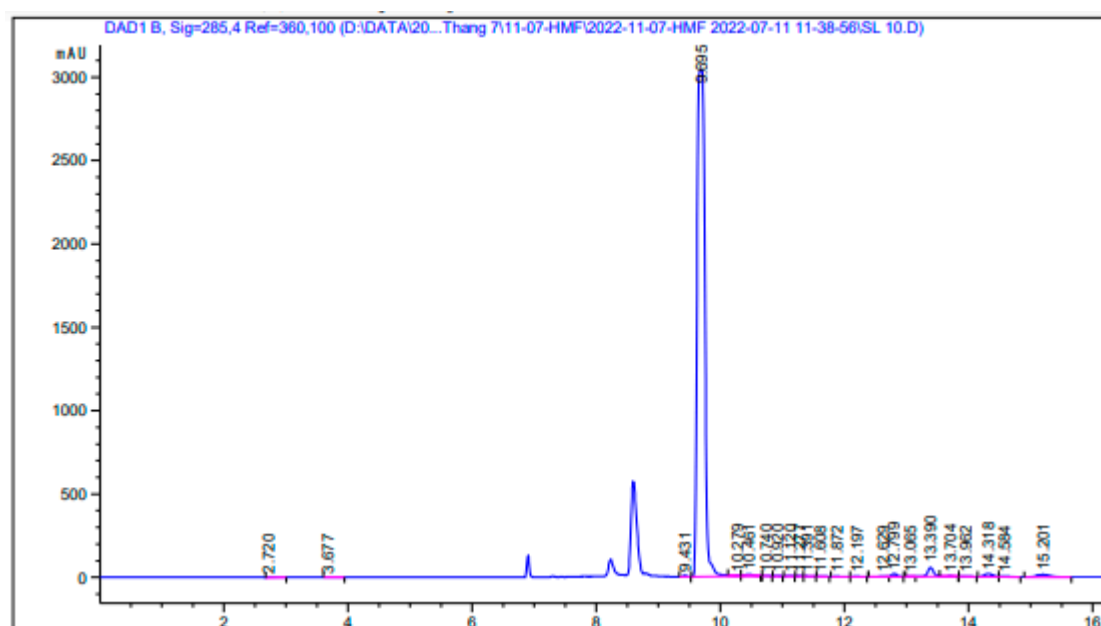


Figure S4. 14: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 3 (5 mmol), 100 °C, 30 min.



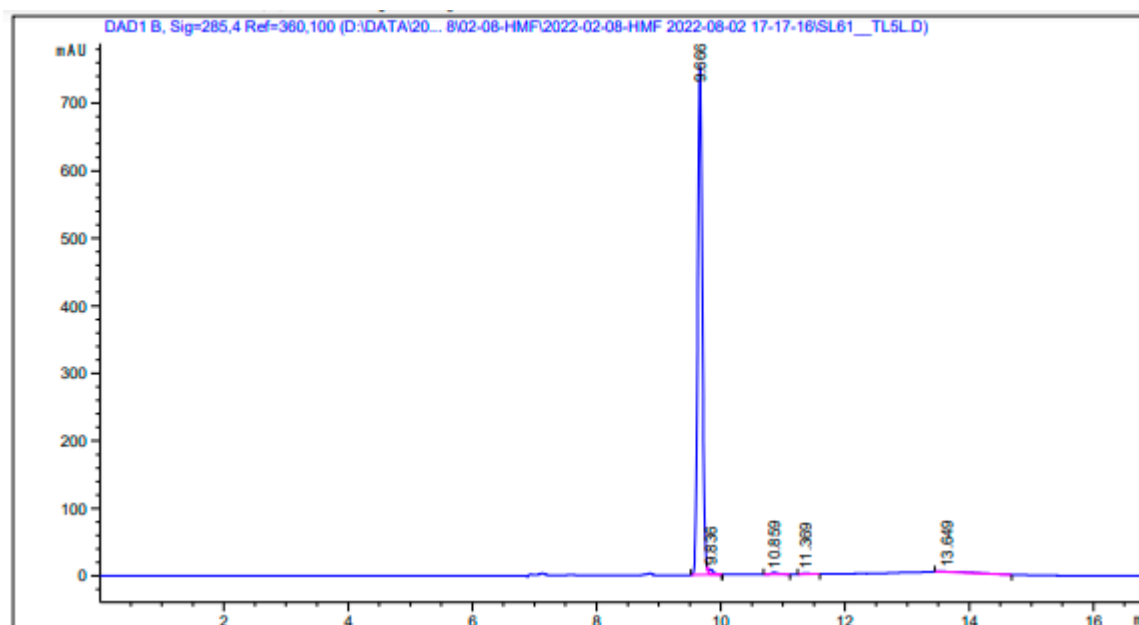
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RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.770	-	-	-	-	-	Levulinic acid
9.695	BV R	2.60188e4	1.06807e-2	277.90030		HMF
10.279	VV E	19.25565	1.72523e-1	3.32204		DFF
10.920	BB	5.08497	3.09133e-1	1.57193		FDCA
11.277	BV	10.84214	0.00000	0.00000		Furfural

Figure S4. 15: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 3 (5 mmol), 100 °C, 60 min.



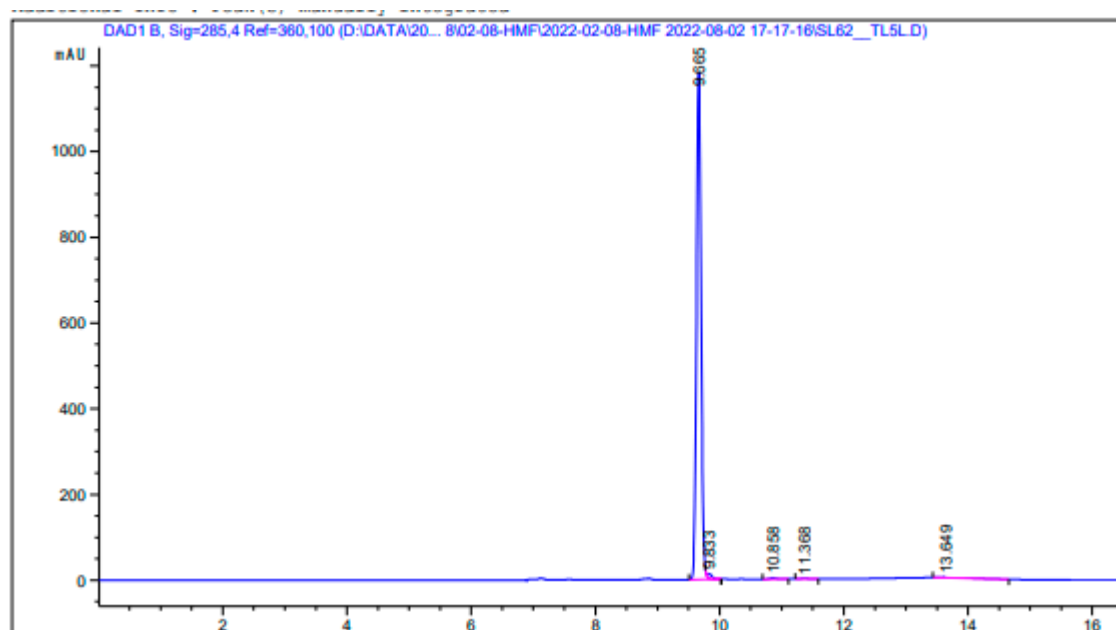
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.666	BV R	3906.31519	9.54739e-3	37.29510	-	HMF
10.501	-	-	-	-	-	DFF
10.859	BB	21.06435	0.00000	0.00000	-	FDCA
11.369	BB	10.89429	0.00000	0.00000	-	Furfural

Figure S4. 16: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 4 (5 mmol), 100 °C, 5 min.



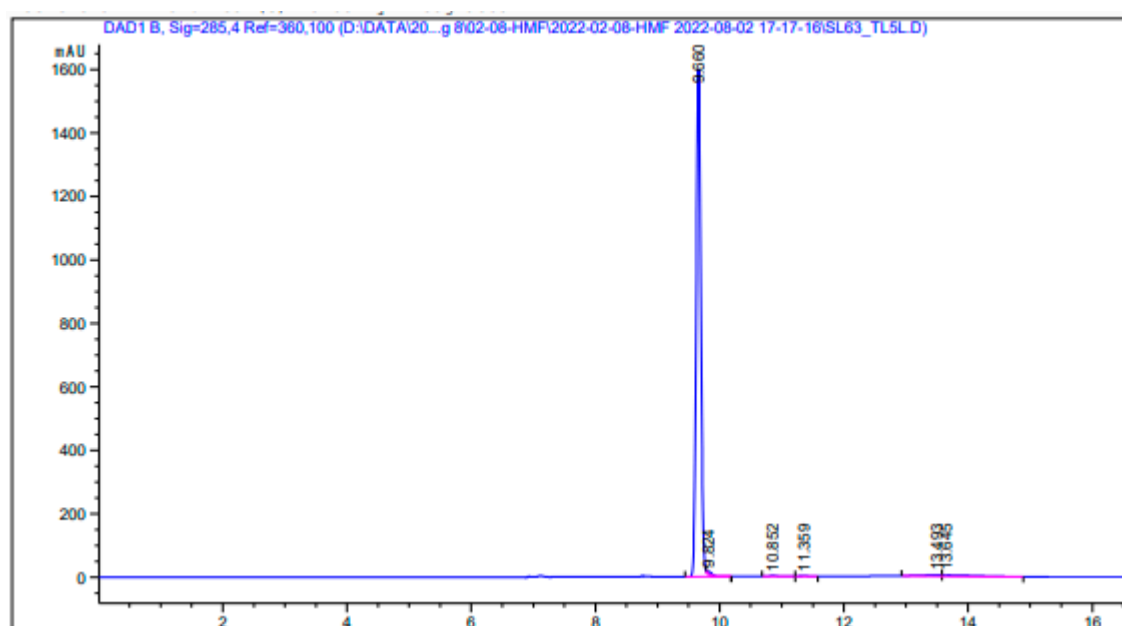
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.665	BV R	6134.12354	9.58444e-3	58.79213	-	HMF
10.501	-	-	-	-	-	DFF
10.858	BB	21.17272	0.00000	0.00000	-	FDCA
11.368	BB	13.81054	0.00000	0.00000	-	Furfural

Figure S4. 17: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 4 (5 mmol), 100 °C, 10 min.



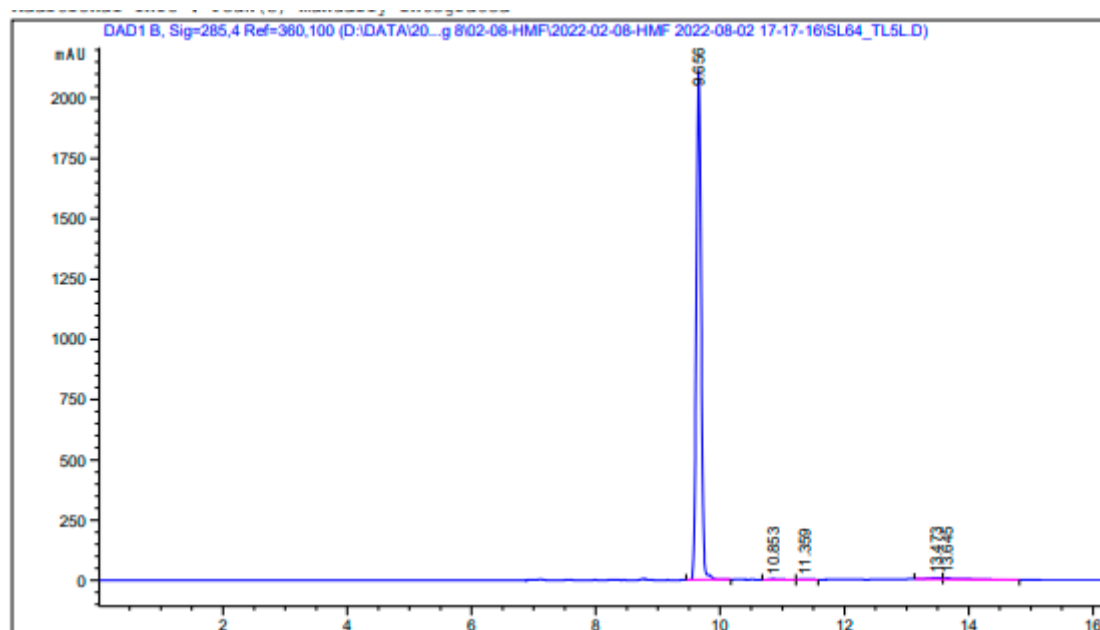
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.660	BV R	8373.49219	9.60181e-3	80.40071		HMF
10.501		-	-	-		DFF
10.852	BV	25.84713	0.00000	0.00000		FDCA
11.359	VB	15.41716	0.00000	0.00000		Furfural

Figure S4. 18: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 4 (5 mmol), 100 °C, 20 min.



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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.656	BB	1.12705e4	9.61405e-3	108.35468	-	HMF
10.501	-	-	-	-	-	DFF
10.853	BV	25.21981	0.00000	0.00000	-	FDCA
11.359	VB	13.95730	0.00000	0.00000	-	Furfural

Figure S4. 19: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 4 (5 mmol), 100 °C, 30 min.

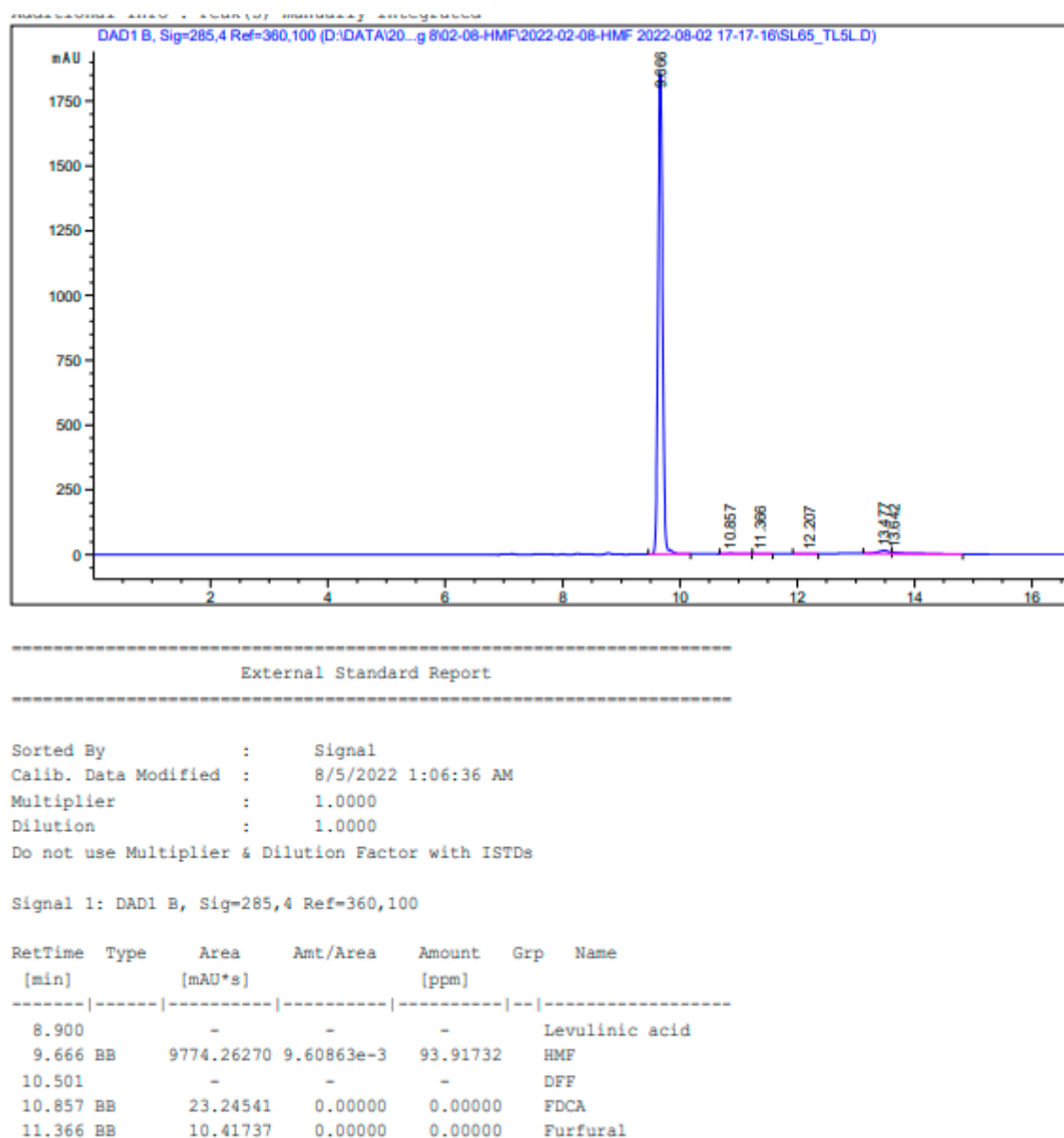
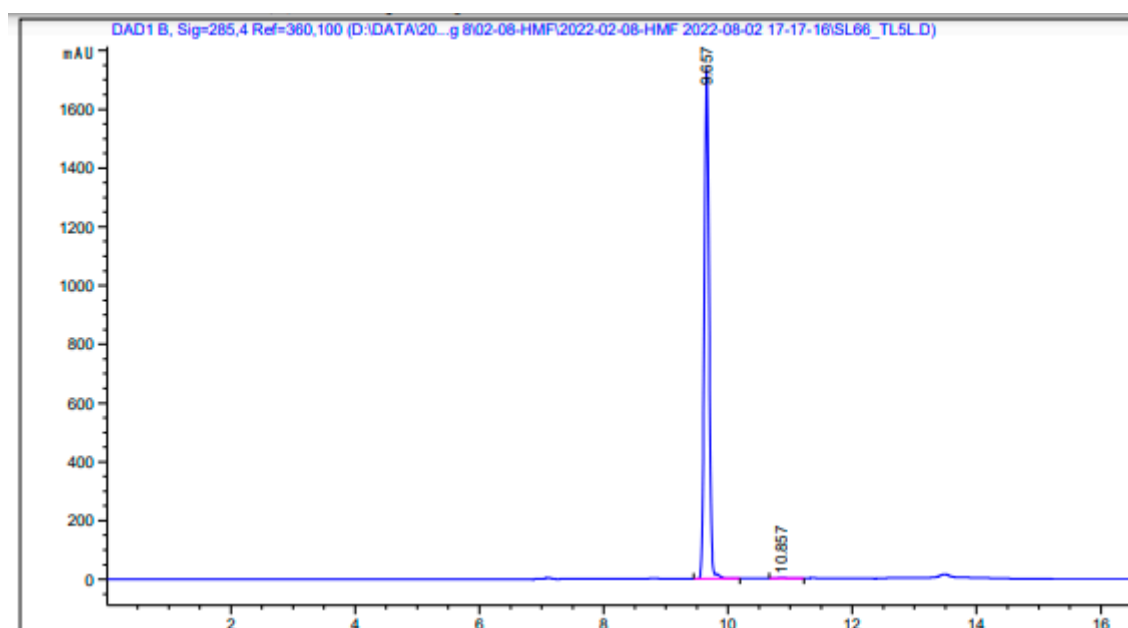


Figure S4. 20: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 4 (5 mmol), 100 °C, 60 min.



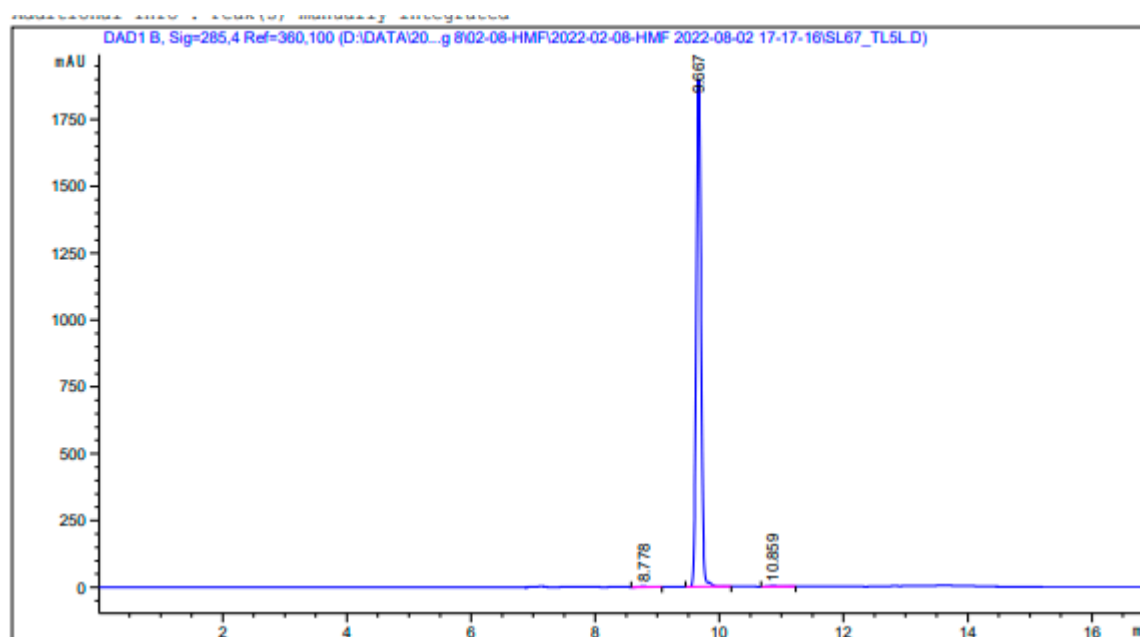
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Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.657	BB	9150.45801	9.60586e-3	87.89798	-	HMF
10.501	-	-	-	-	-	DFF
10.857	BB	22.54233	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 21. HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 5 (5 mmol), 100 °C, 5 min.



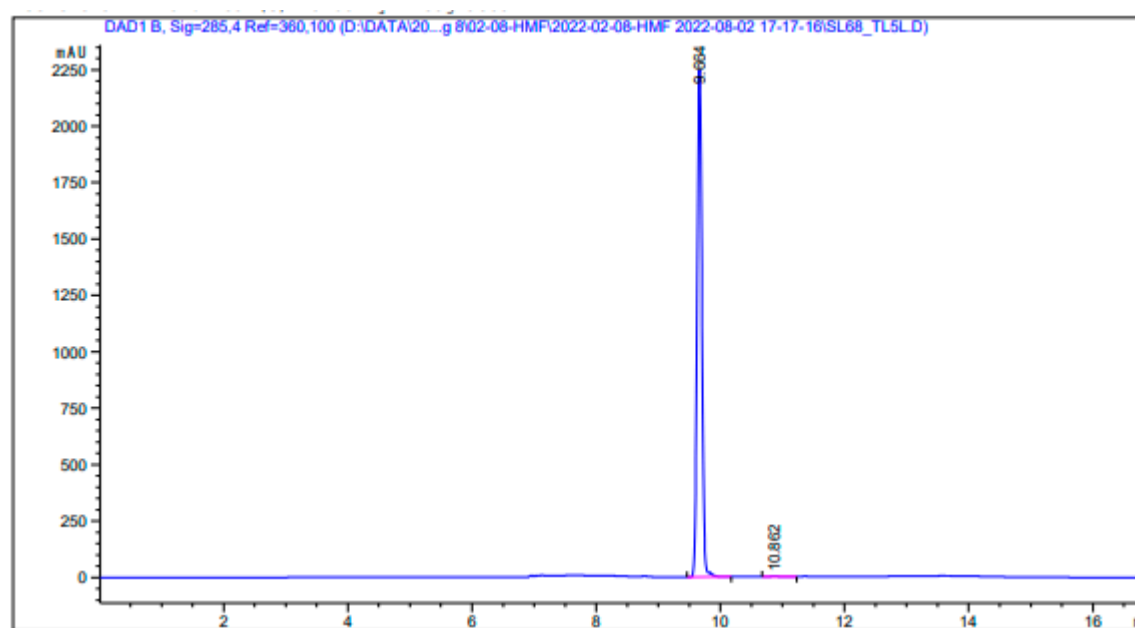
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.778	BB	23.10656	19.27242	445.31937		Levulinic acid
9.667	BB	1.00511e4	9.60976e-3	96.58897		HMF
10.501		-	-	-		DFF
10.859	BV	25.13309	0.00000	0.00000		FDCA
11.300		-	-	-		Furfural

Figure S4. 22: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 5 (5 mmol), 100 °C, 10 min.



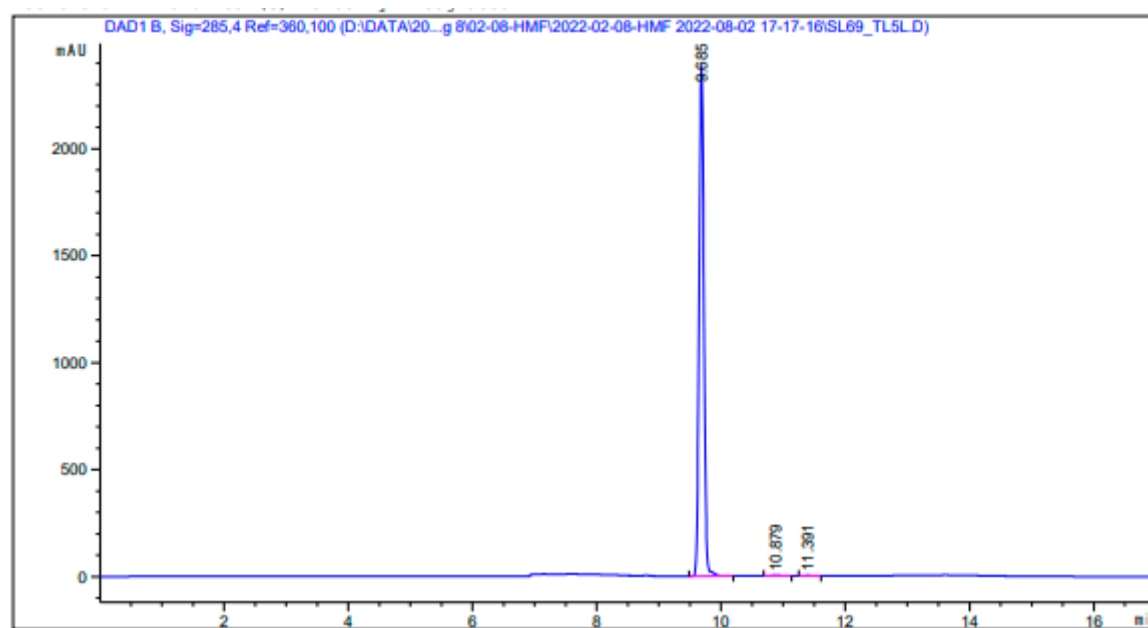
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.664	BB	1.20256e4	9.61627e-3	115.64122	-	HMF
10.501	-	-	-	-	-	DFF
10.862	BB	24.84221	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 23: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 5 (5 mmol), 100 °C, 20 min.



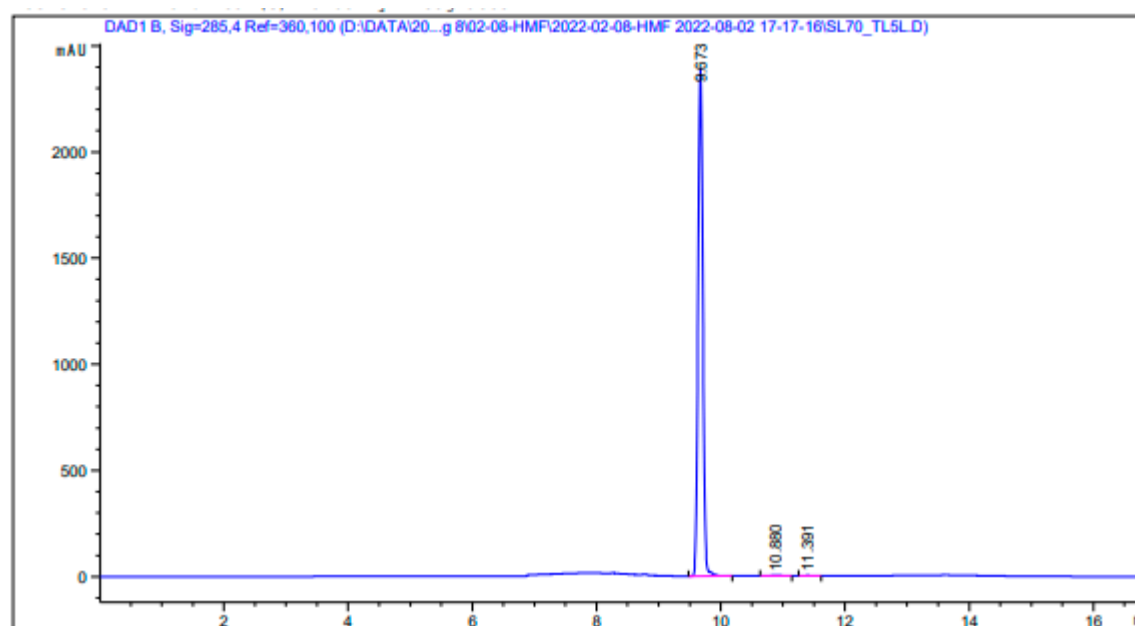
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.685	BB	1.28581e4	9.61841e-3	123.67452	-	HMF
10.501	-	-	-	-	-	DFF
10.879	BB	23.64330	0.00000	0.00000	-	FDCA
11.391	BB	14.25451	0.00000	0.00000	-	Furfural

Figure S4. 24. HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 5 (5 mmol), 100 °C, 30 min.



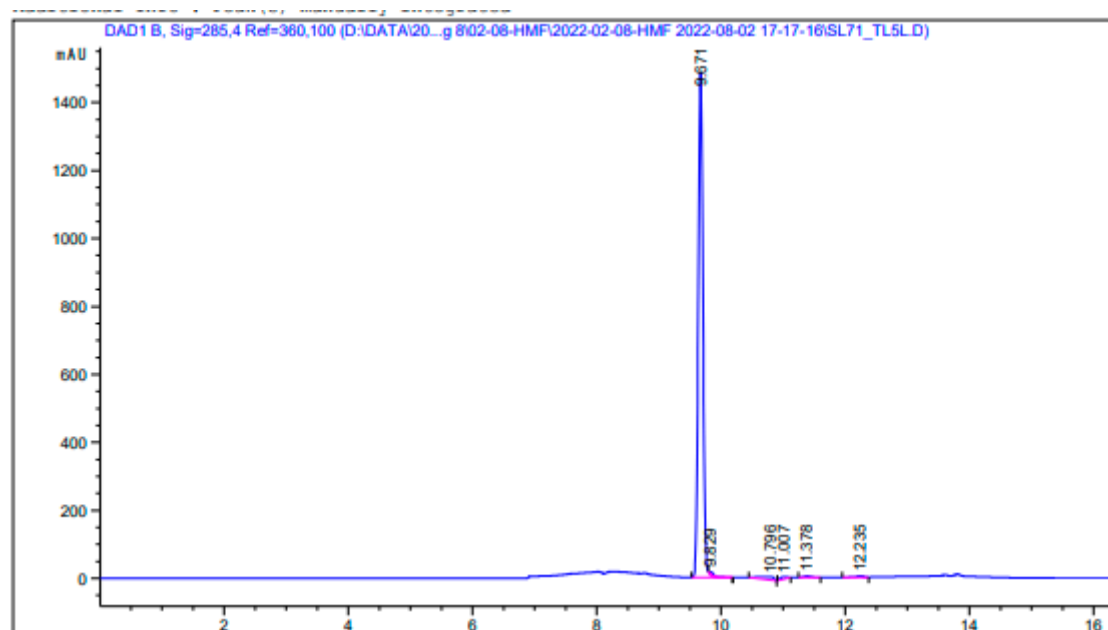
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.673	BB	1.29810e4	9.61871e-3	124.86015	-	HMF
10.501	-	-	-	-	-	DFF
10.880	BB	34.59396	0.00000	0.00000	-	FDCA
11.391	BB	13.26276	0.00000	0.00000	-	Furfural

Figure S4. 25: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 5 (5 mmol), 100 °C, 60 min.



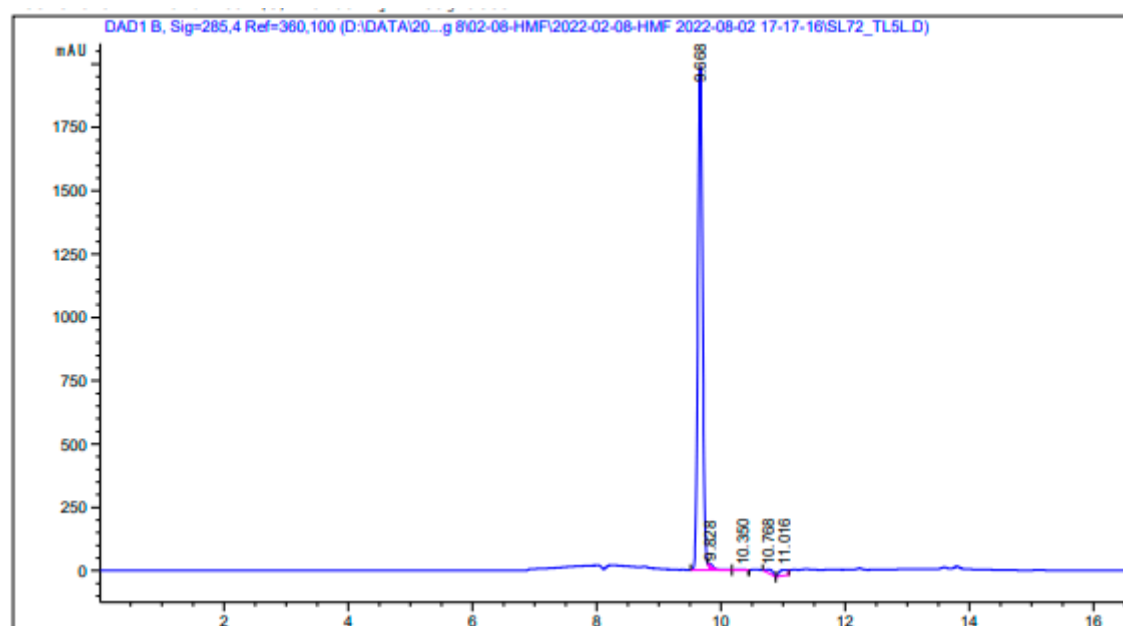
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.671	BV R	7788.48291	9.59824e-3	74.75572	-	HMF
10.501	-	-	-	-	-	DFF
11.007	BB	47.10159	0.00000	0.00000	-	FDCA
11.378	BB	23.25702	0.00000	0.00000	-	Furfural

Figure S4. 26. HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 6 (5 mmol), 100 °C, 5 min.



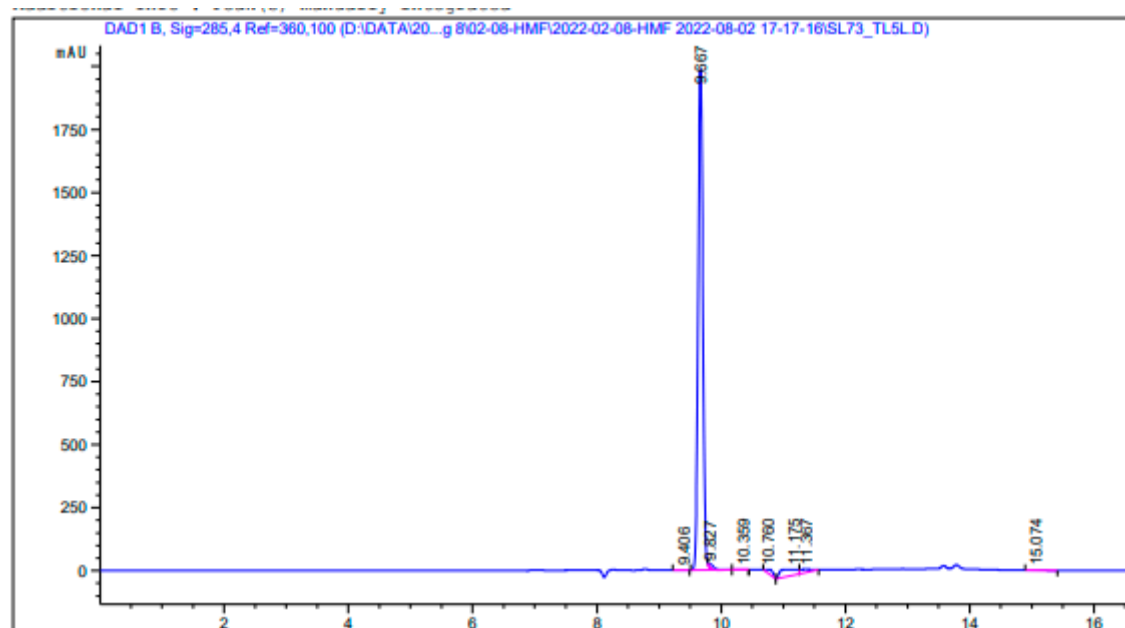
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.668	BV R	1.04631e4	9.61132e-3	100.56388	-	HMF
10.350	VB E	7.35093	5.43150e-2	3.99266e-1	-	DFF
11.016	BV	210.33058	7.56799e-2	15.91780	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 27: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 6 (5 mmol), 100 °C, 10 min.



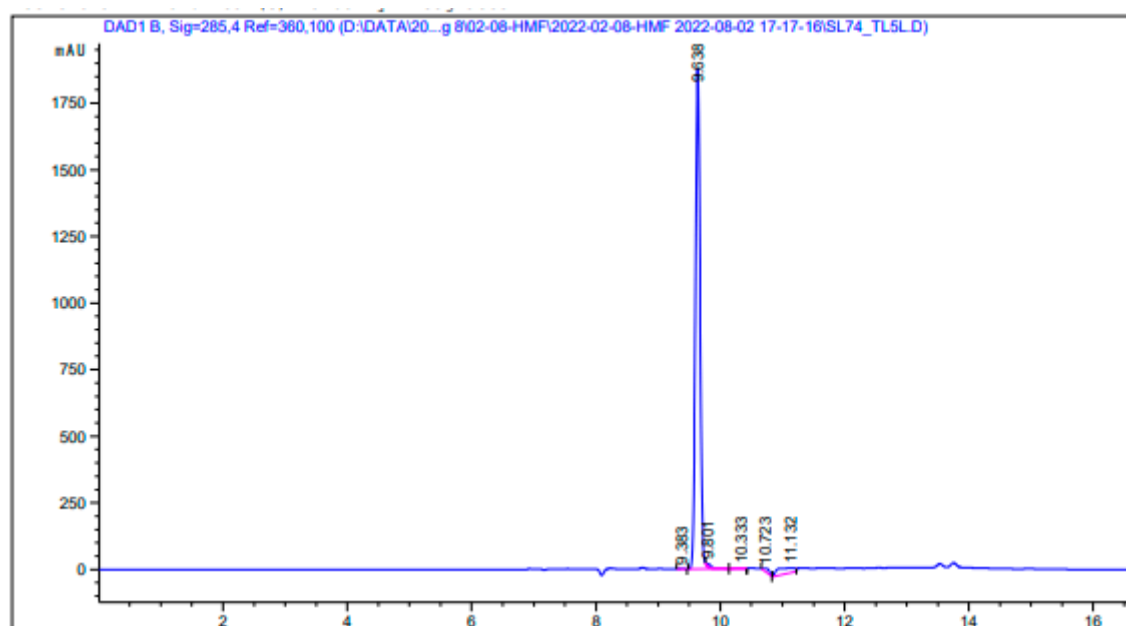
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.667	BV R	1.03970e4	9.61108e-3	99.92665	-	HMF
10.359	VB E	8.28941	4.93434e-2	4.09028e-1	-	DFF
11.175	BV	492.47964	1.30781e-1	64.40692	-	FDCA
11.367	VB	164.02460	8.69208e-3	1.42571	-	Furfural

Figure S4. 28. HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 5 (5 mmol), 100 °C, 20 min.



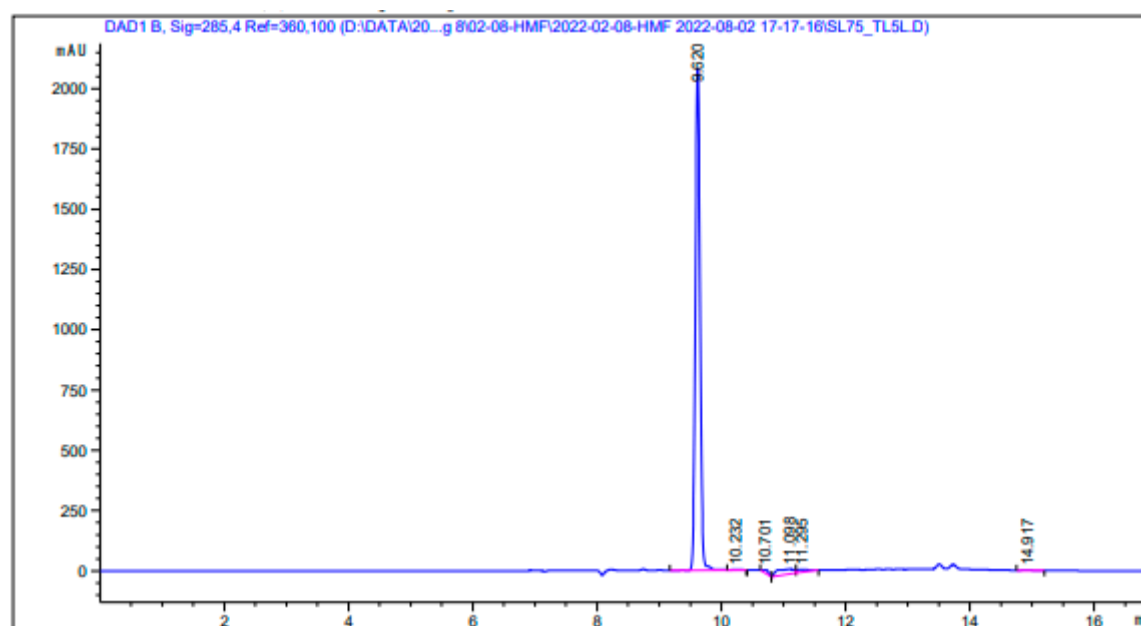
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.638	BV R	9790.12500	9.60870e-3	94.07038	-	HMF
10.333	VB E	9.75259	4.35011e-2	4.24248e-1	-	DFF
11.132	BV	408.80066	1.22373e-1	50.02615	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 29: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 6 (5 mmol), 100 °C, 30 min.



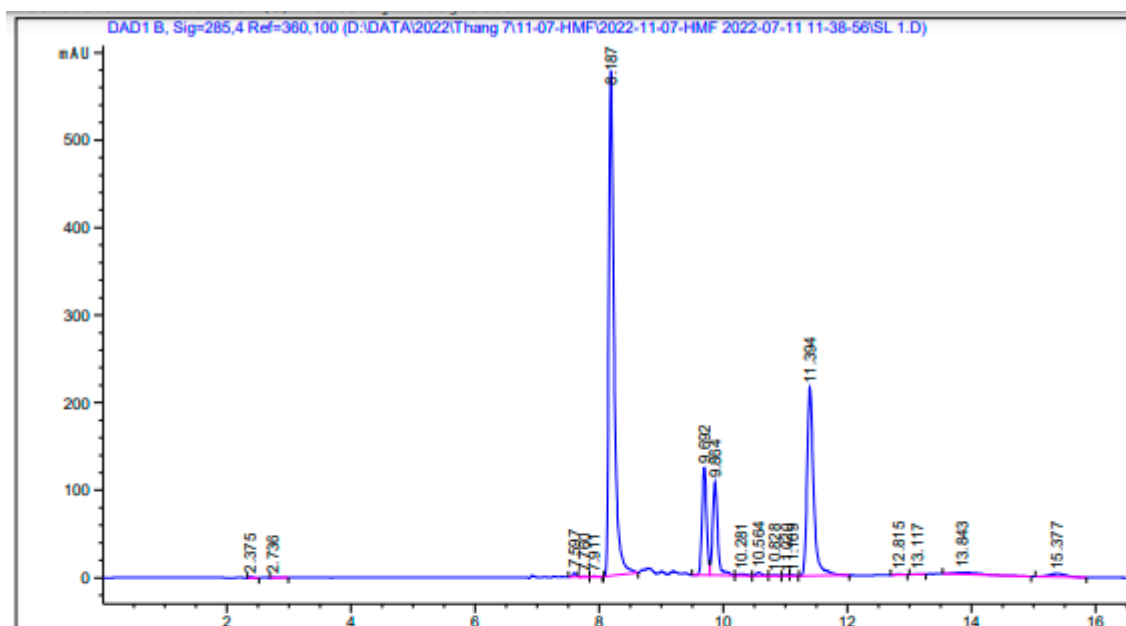
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.620	VV R	1.09698e4	9.61308e-3	105.45313		HMF
10.701	BB	88.05828	1.40676e-2	1.23877		DFF
11.098	BV	428.39117	1.24636e-1	53.39291		FDCA
11.295	VB	153.40373	8.58660e-3	1.31722		Furfural

Figure S4. 30: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 6 (5 mmol), 100 °C, 60 min.



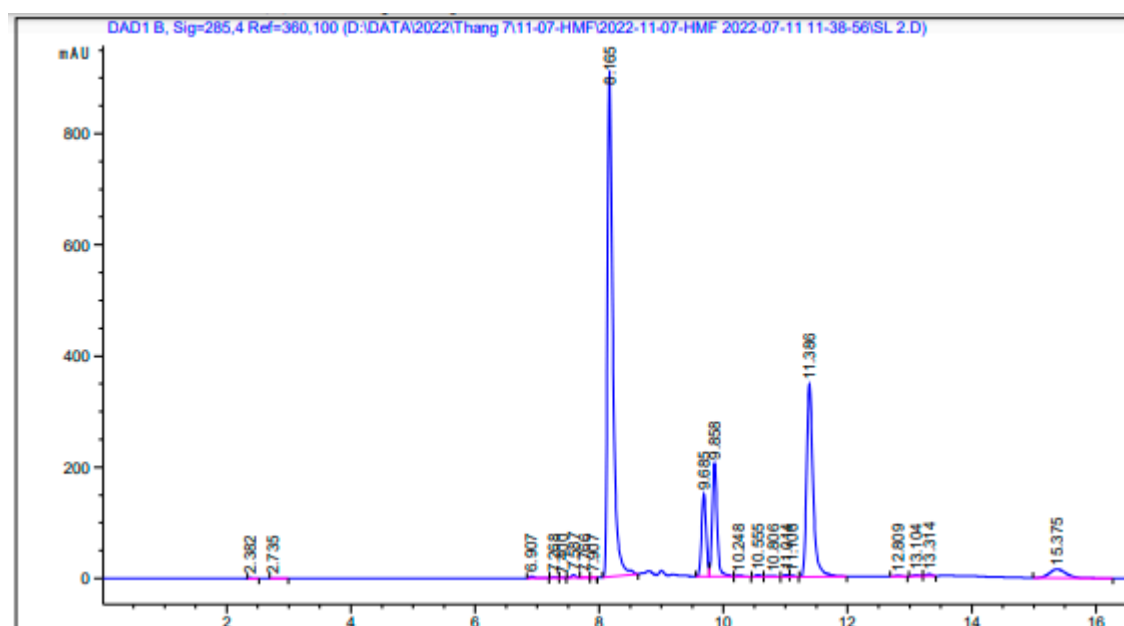
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.770	-	-	-	-	-	Levulinic acid
9.692	BV	630.08673	1.38536e-2	8.72899		HMF
10.281	BB	17.19796	1.91958e-1	3.30128		DFF
11.020	BV	5.93214	2.79086e-1	1.65558		FDCA
11.394	BB	1588.69324	7.99980e-2	127.09226		Furfural

Figure S4. 31: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 7 (5 mmol), 100 °C, 5 min.



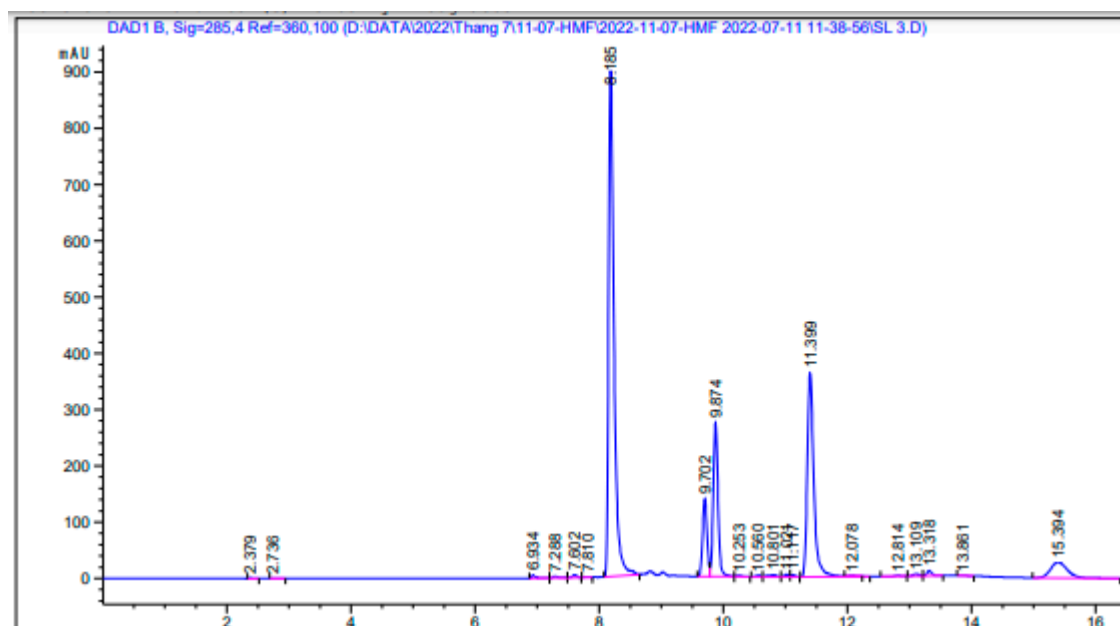
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.770	-	-	-	-	-	Levulinic acid
9.685	BV	746.60907	1.33461e-2	9.96436		HMF
10.248	BB	13.64233	2.39359e-1	3.26542		DFF
11.014	BV	18.77409	1.55725e-1	2.92360		FDCA
11.386	BB	2519.22363	8.89755e-2	224.14906		Furfural

Figure S4. 32: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 7 (5 mmol), 100 °C, 10 min.



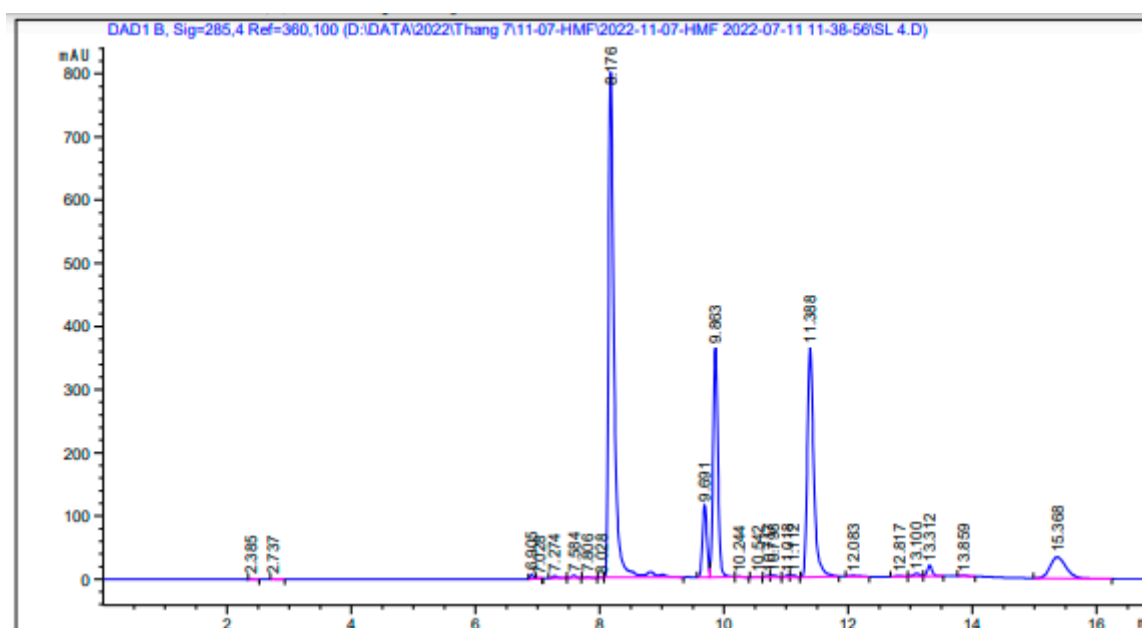
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.770	-	-	-	-	-	Levulinic acid
9.702	BV	691.44653	1.35651e-2	9.37952		HMF
10.253	BB	9.75795	3.30626e-1	3.22623		DFF
11.021	VV	22.30971	1.46695e-1	3.27271		FDCA
11.399	BV R	2674.48364	8.98652e-2	240.34309		Furfural

Figure S4. 33: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 7 (5 mmol), 100 °C, 20 min.



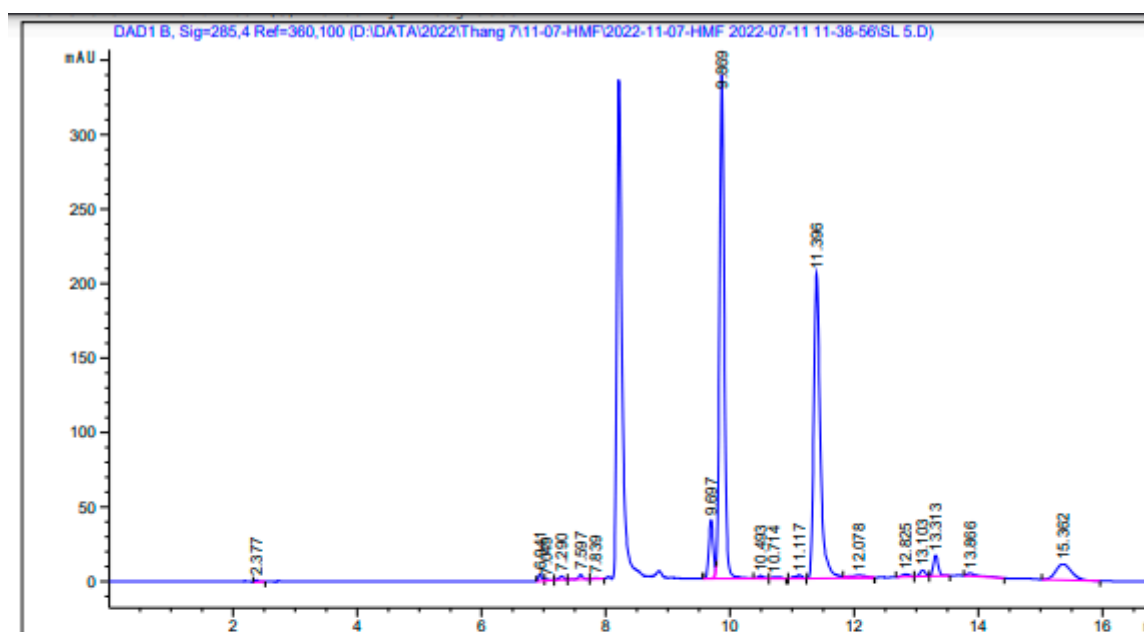
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.770	-	-	-	-	-	Levulinic acid
9.691	BV	570.74200	1.41917e-2	8.09982	-	HMF
10.244	BB	4.51703	7.02534e-1	3.17337	-	DFF
11.018	BV	15.42087	1.68117e-1	2.59251	-	FDCA
11.388	BB	2624.86206	8.95923e-2	235.16743	-	Furfural

Figure S4. 34: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 7 (5 mmol), 100 °C, 30 min.



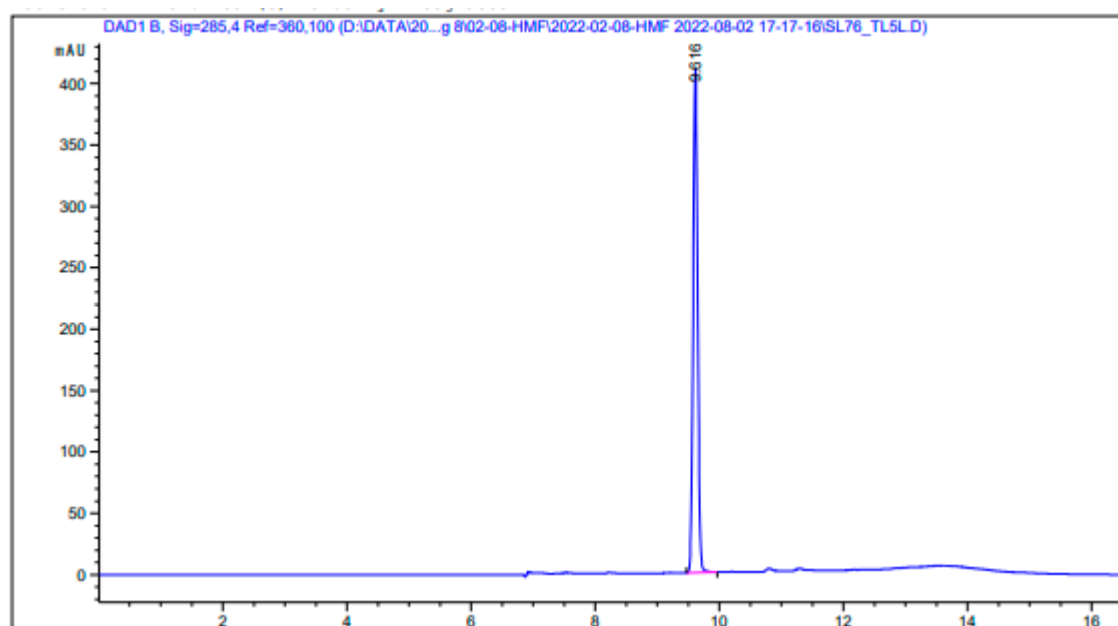
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.770	-	-	-	-	-	Levulinic acid
9.697	BV E	192.19151	2.12623e-2	4.08643	HMF	
10.493	VV E	10.38449	3.11287e-1	3.23255	DFF	
11.117	BB	19.93857	1.52397e-1	3.03859	FDCA	
11.396	BV R	1494.61084	7.84681e-2	117.27922	Furfural	

Figure S4. 35: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 7 (5 mmol), 100 °C, 60 min.



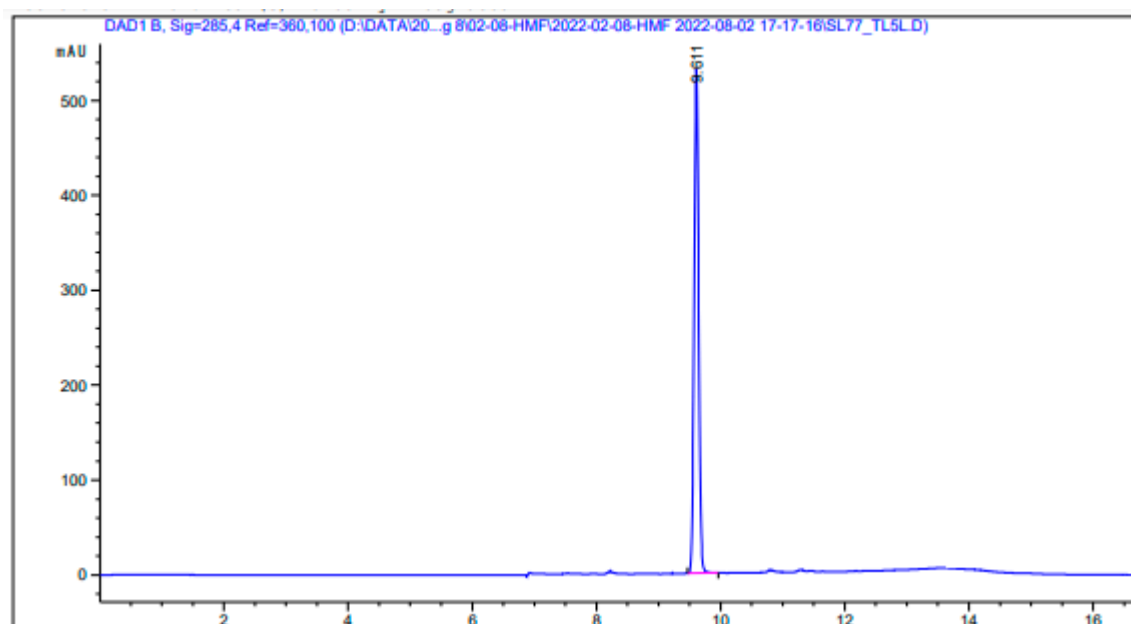
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.616	BB	2094.48608	9.45913e-3	19.81201	-	HMF
10.501	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 36. HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 8 (5 mmol), 100 °C, 5 min.



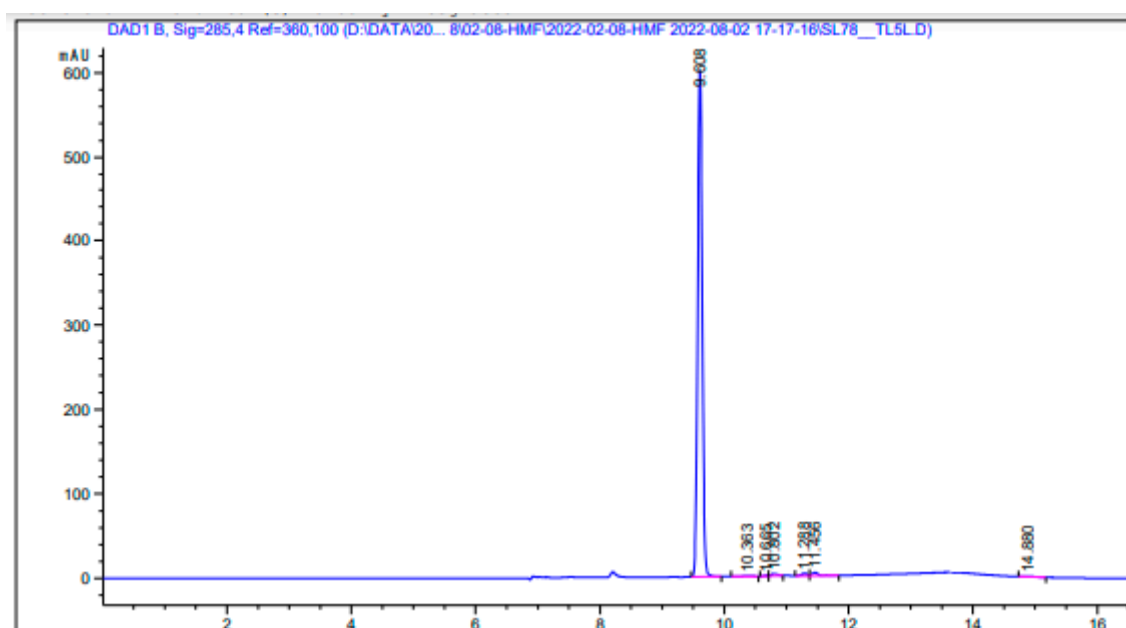
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.611	BB	2707.33618	9.50220e-3	25.72566	-	HMF
10.501	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 37: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 8 (5 mmol), 100 °C, 10 min.



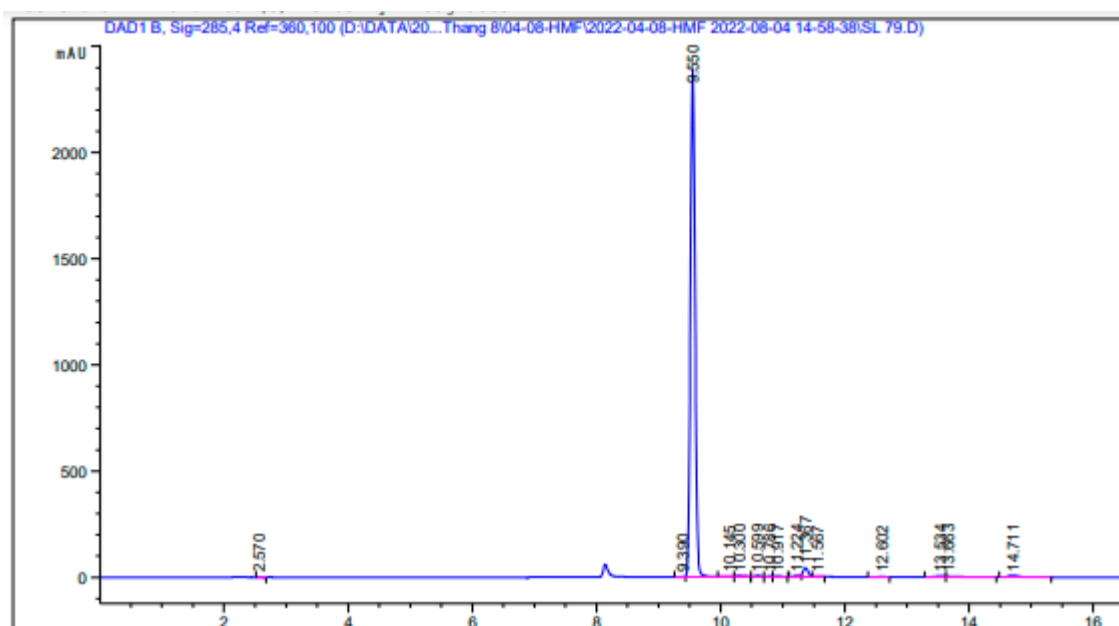
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.608	BB	3058.57422	9.51911e-3	29.11490		HMF
10.363	BB	9.35254	4.49168e-2	4.20087e-1		DFF
11.097		-	-	-		FDCA
11.288	BV	16.72079	0.00000	0.00000		Furfural

Figure S4. 38: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 8 (5 mmol), 100 °C, 20 min.



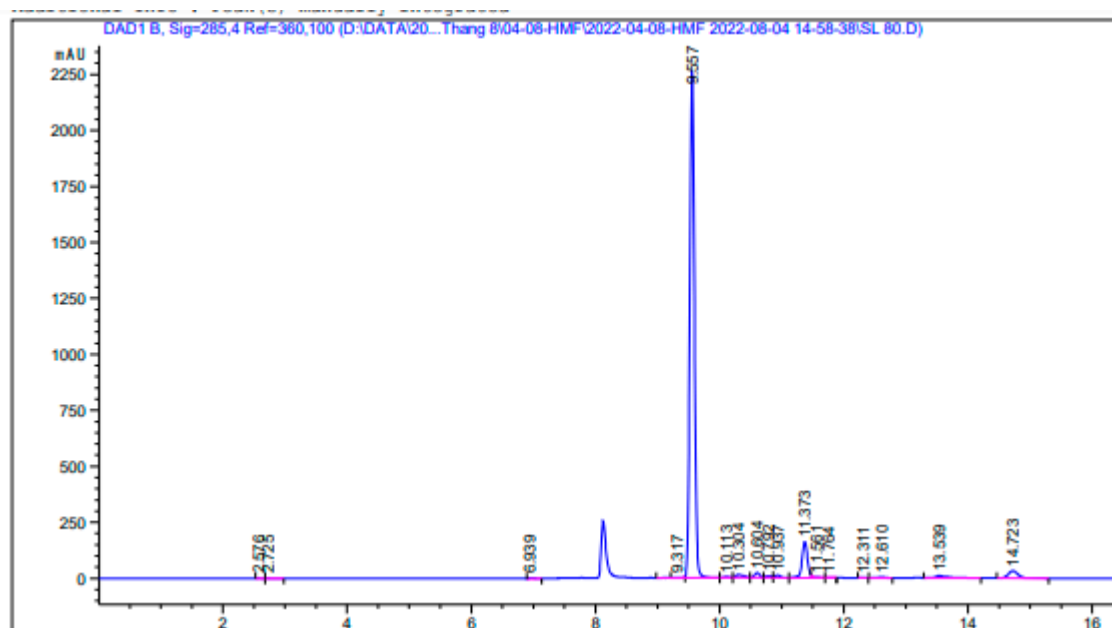
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.550	VV R	1.24680e4	9.61744e-3	119.91003		HMF
10.599	BB	32.32678	2.03875e-2	6.59061e-1		DFF
11.224	BV E	27.93352	0.00000	0.00000		FDCA
11.367	VV R	256.97153	9.24310e-3	2.37521		Furfural

Figure S4. 39: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 8 (5 mmol), 100 °C, 30 min.



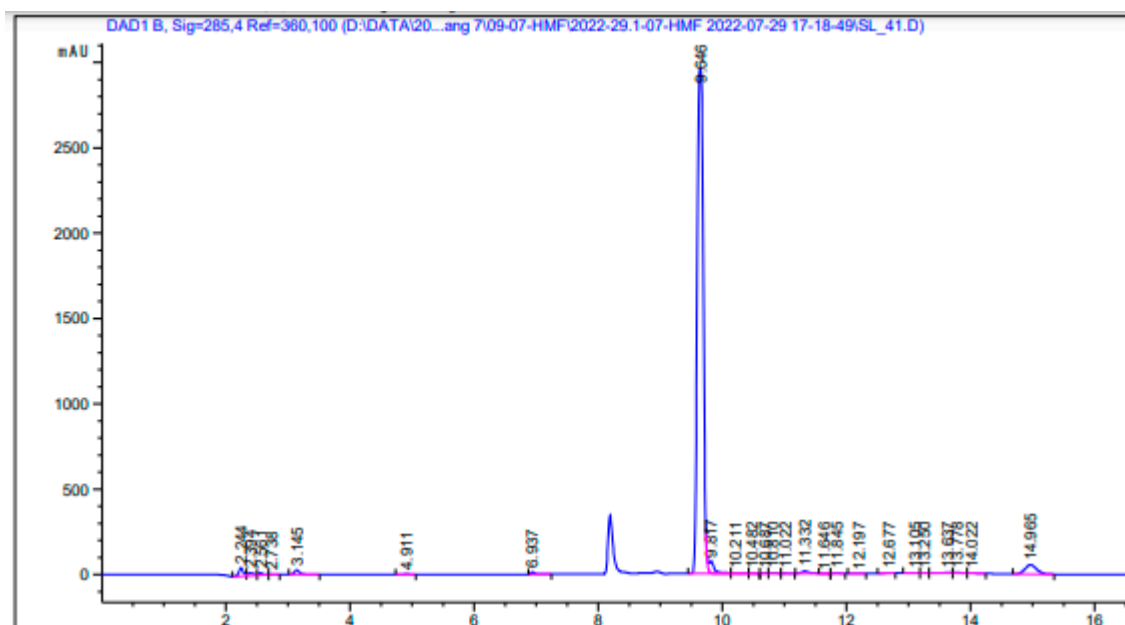
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.557	VB R	1.17089e4	9.61537e-3	112.58580		HMF
10.604	BV	117.79538	1.31422e-2	1.54809		DFF
10.937	VB	67.68656	0.00000	0.00000		FDCA
11.373	BV R	984.14758	9.96159e-3	9.80368		Furfural

Figure S4. 40: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 8 (5 mmol), 100 °C, 60 min.



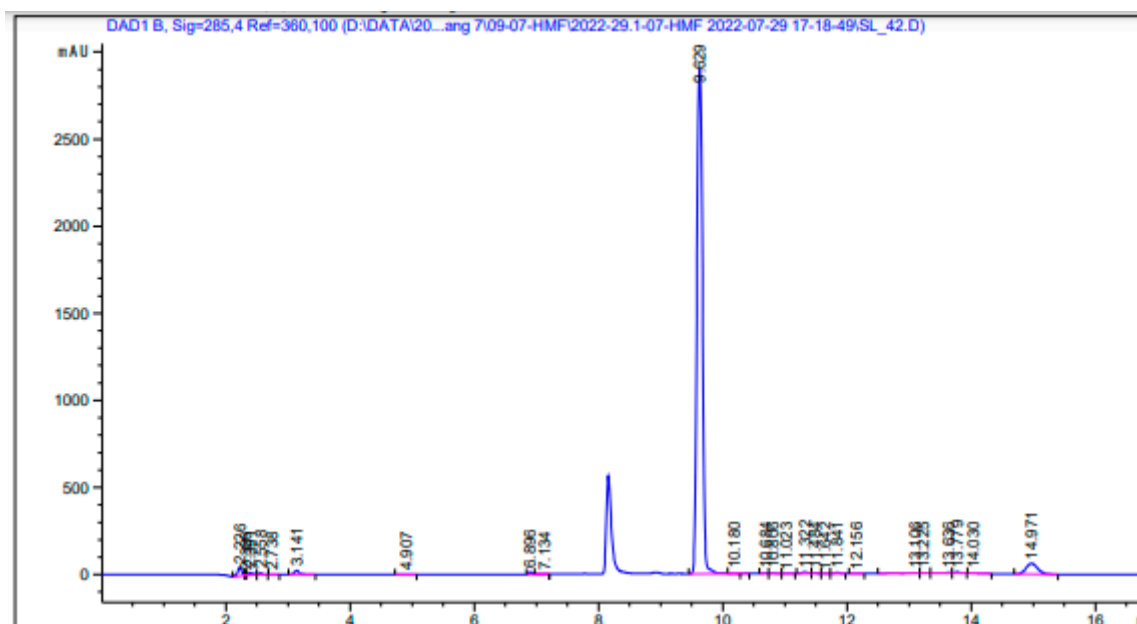
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.646	BV R	2.02014e4	9.62968e-3	194.53319		HMF
10.211	VV E	55.94803	1.61715e-2	9.04766e-1		DFF
11.022	BB	3.71712	0.00000	0.00000		FDCA
11.332	BV R	104.59485	7.82649e-3	8.18610e-1		Furfural

Figure S4. 41. HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 9 (5 mmol), 100 °C, 5 min.



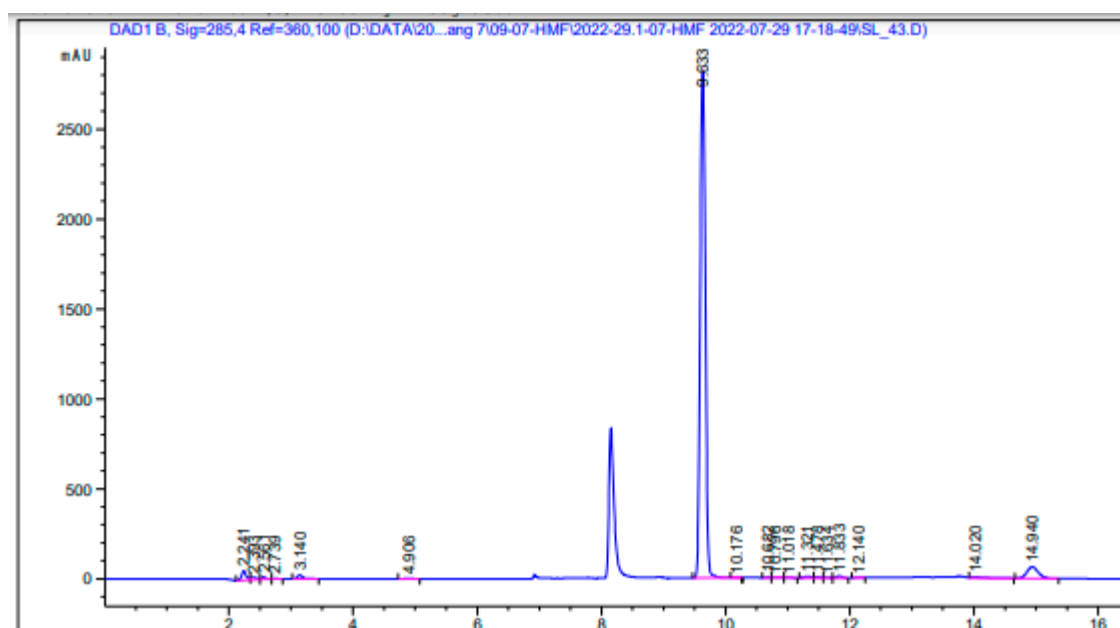
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.629	BV R	1.80241e4	9.62730e-3	173.52315		HMF
10.180	VV E	5.10005	7.36959e-2	3.75853e-1		DFF
11.023	BB	6.20005	0.00000	0.00000		FDCA
11.322	BV	56.48049	5.79134e-3	3.27098e-1		Furfural

Figure S4. 42: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 9 (5 mmol), 100 °C, 10 min.



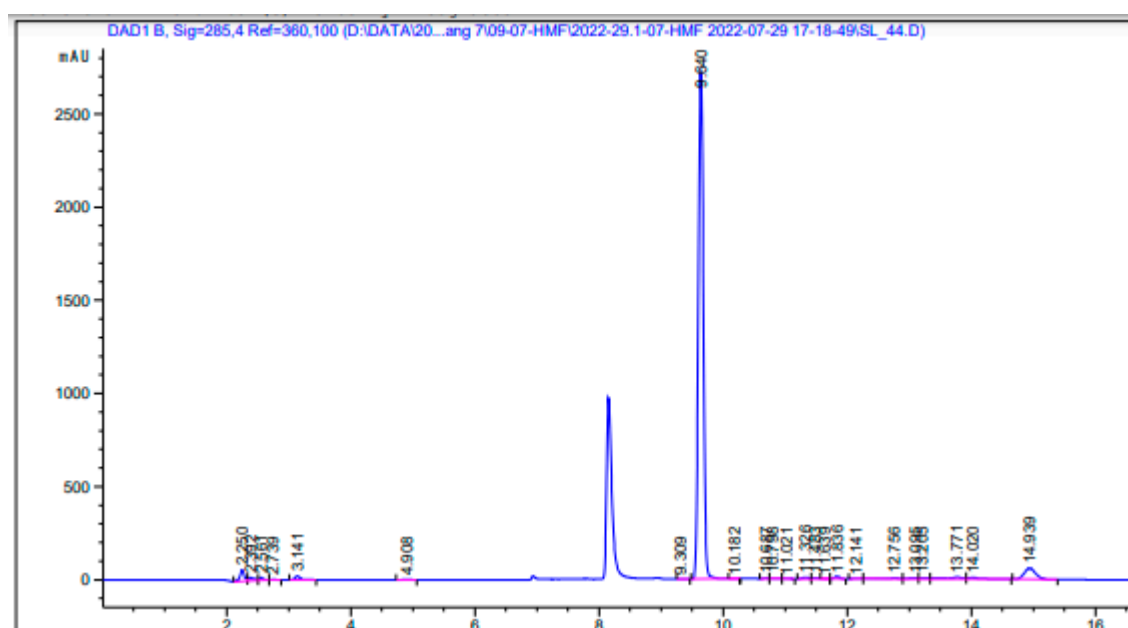
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.633	BV R	1.63927e4	9.62510e-3	157.78146		HMF
10.176	VB E	4.81548	7.74362e-2	3.72893e-1		DFF
11.018	BB	8.26740	0.00000	0.00000		FDCA
11.321	BV	57.90589	5.90025e-3	3.41659e-1		Furfural

Figure S4. 43: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 9 (5 mmol), 100 °C, 20 min.



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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.640	BV R	1.52517e4	9.62328e-3	146.77145		HMF
10.182	VB E	5.63657	6.76712e-2	3.81434e-1		DFF
11.021	BB	9.22130	0.00000	0.00000		FDCA
11.326	BV	55.59239	5.72067e-3	3.18026e-1		Furfural

Figure S4. 44: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 9 (5 mmol), 100 °C, 30 min.

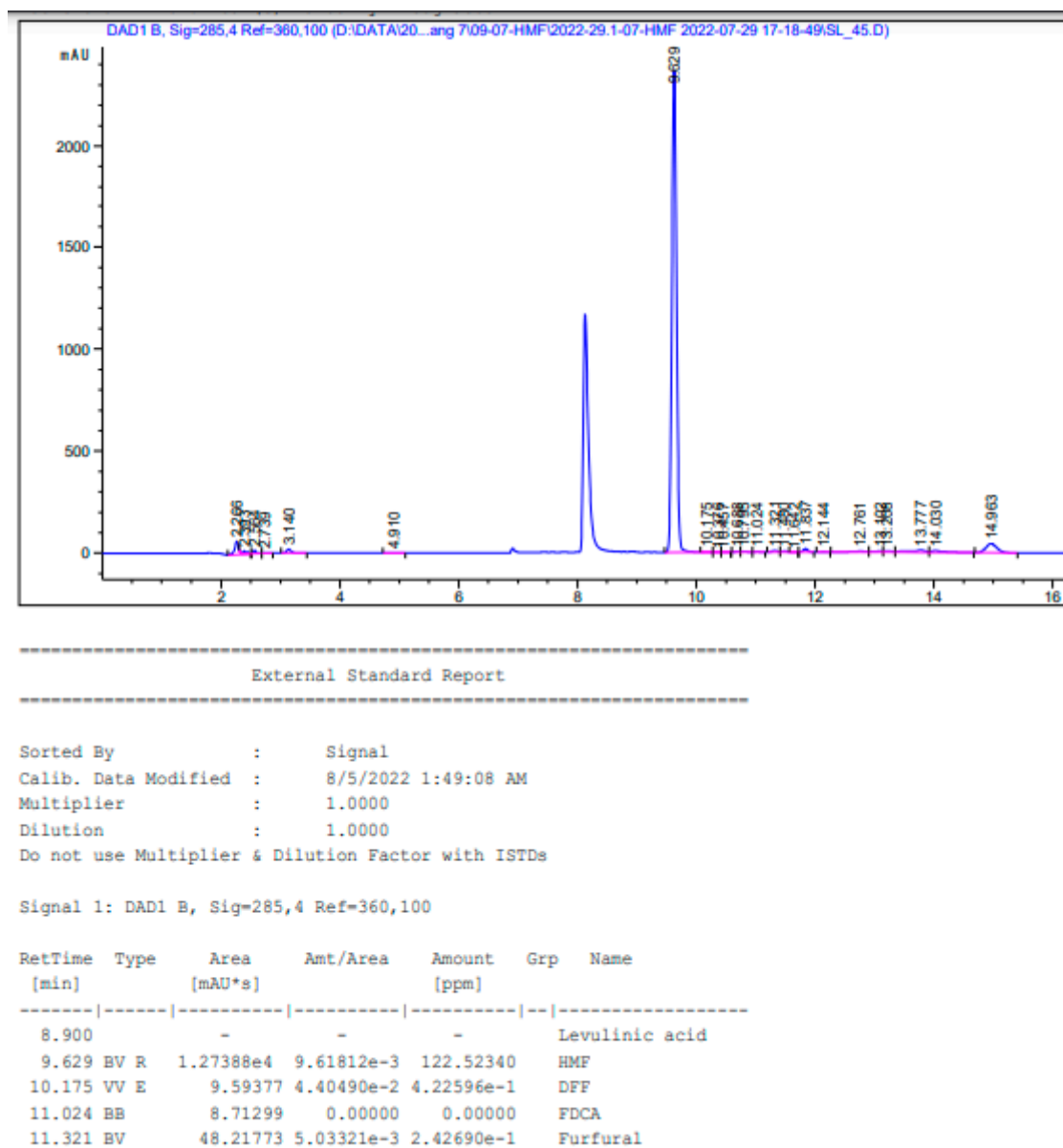
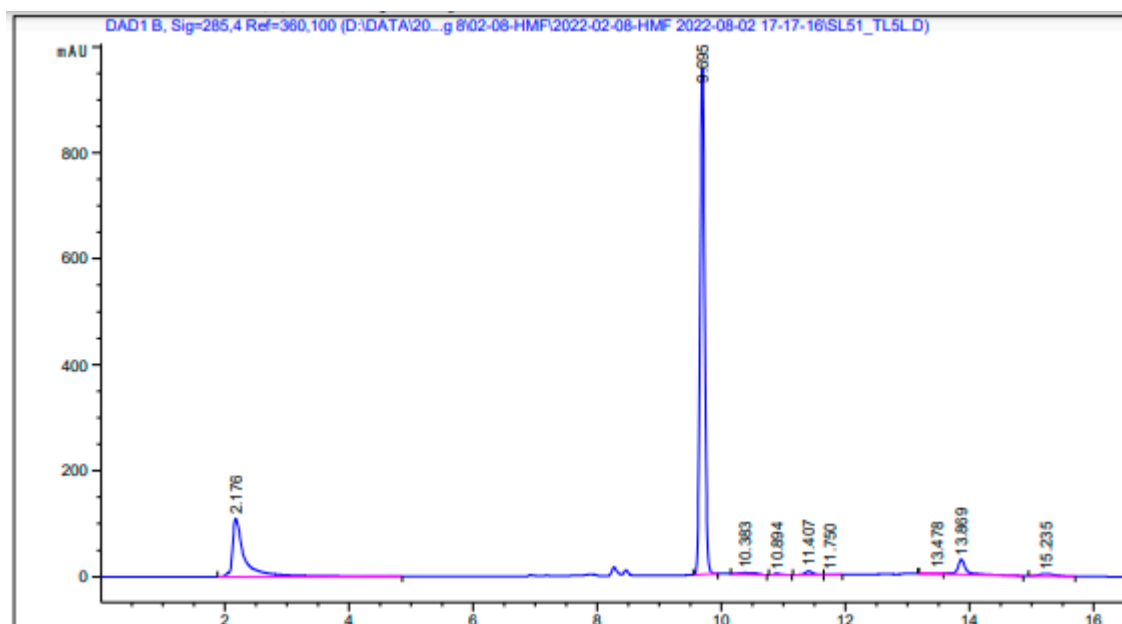


Figure S4. 45: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 9 (5 mmol), 100 °C, 60 min.



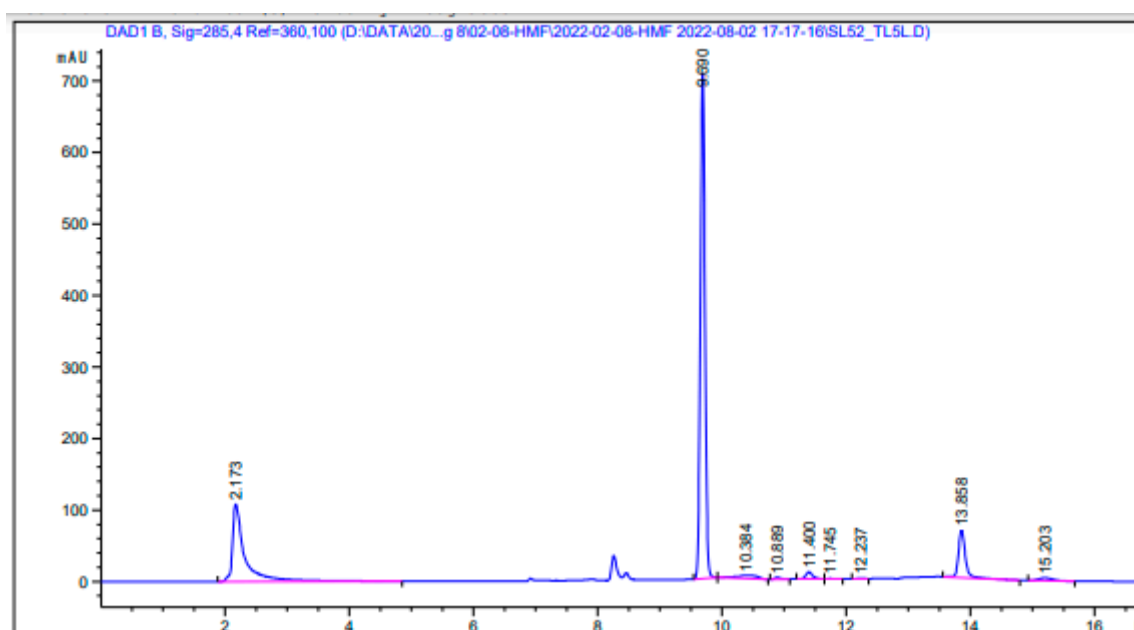
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.695	BB	4935.60938	9.56866e-3	47.22718		HMF
10.383	BB	65.41271	1.53367e-2	1.00322		DFF
10.894	BB	21.08631	0.00000	0.00000		FDCA
11.407	BV	54.58800	5.63797e-3	3.07765e-1		Furfural

Figure S4. 46. HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 10 (5 mmol), 100 °C, 5 min.



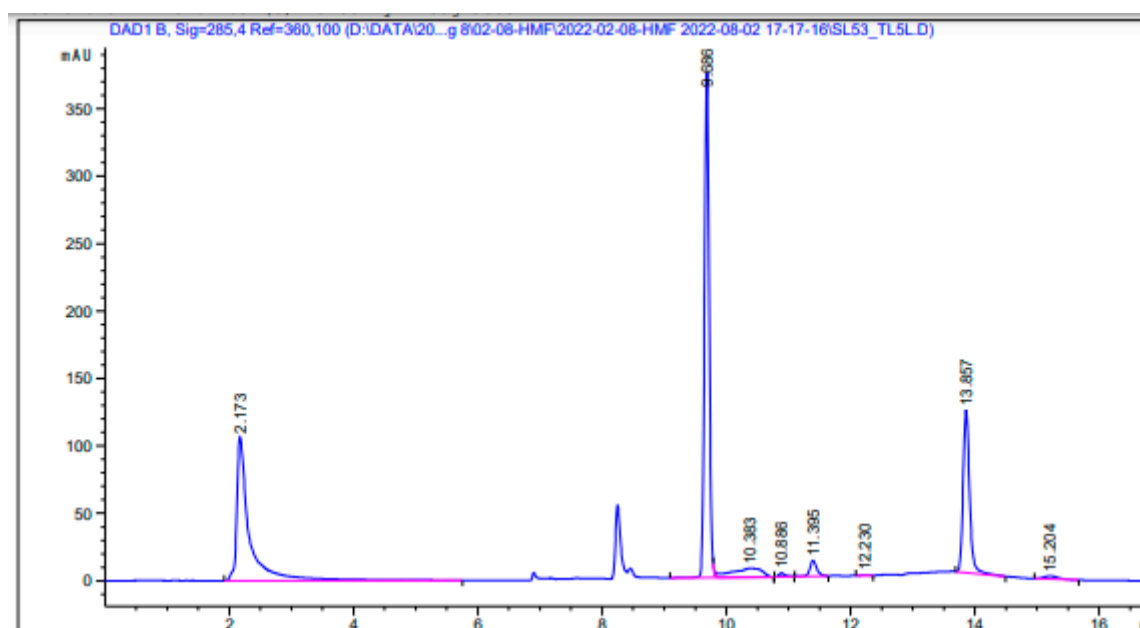
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.690	BB	3651.02319	9.54025e-3	34.83168		HMF
10.384	BB	114.05468	1.32321e-2	1.50918		DFF
10.889	BB	18.42808	0.00000	0.00000		FDCA
11.400	BV	74.78346	6.87414e-3	5.14072e-1		Furfural

Figure S4. 47: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 10 (5 mmol), 100 °C, 10 min.



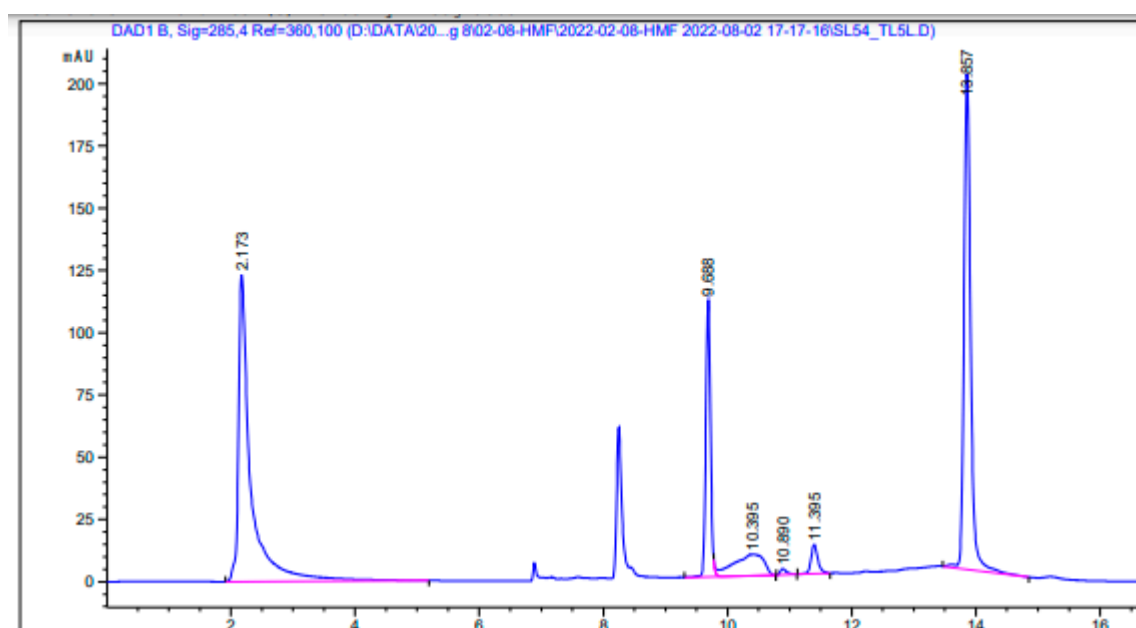
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.686	BV R	1945.79761	9.44459e-3	18.37726		HMF
10.383	VB E	230.53564	1.18021e-2	2.72080		DFF
10.886	BB	17.67013	0.00000	0.00000		FDCA
11.395	BB	87.24858	7.35152e-3	6.41409e-1		Furfural

Figure S4. 48: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 10 (5 mmol), 100 °C, 20 min.



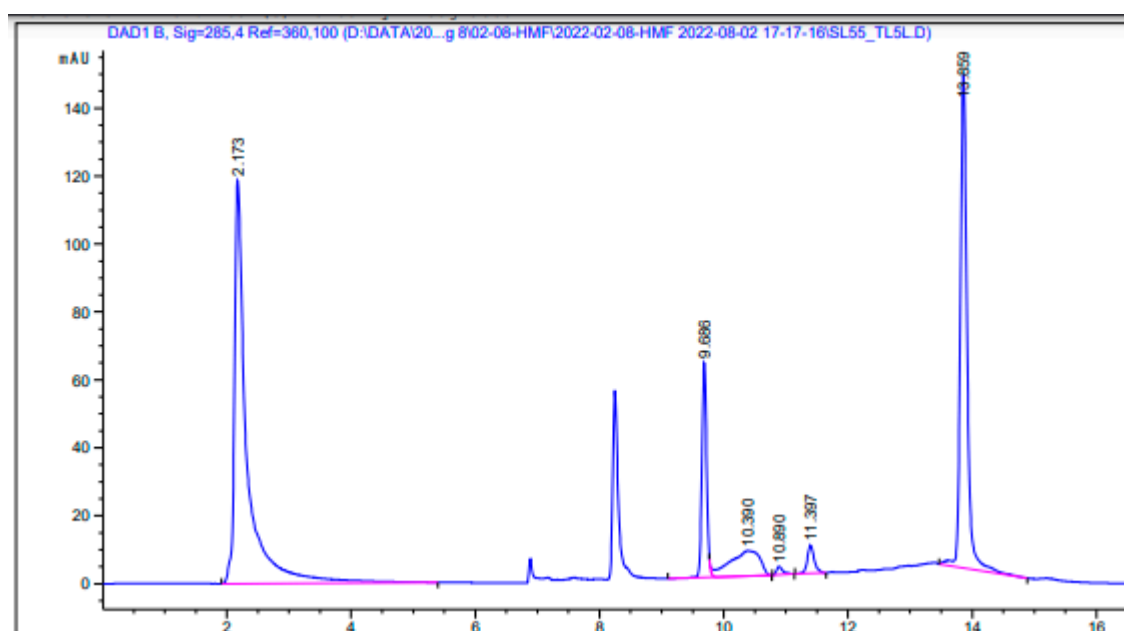
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.688	BV R	585.88055	8.96917e-3	5.25486		HMF
10.395	VB E	295.59583	1.14939e-2	3.39755		DFF
10.890	BB	17.18932	0.00000	0.00000		FDCA
11.395	BB	88.53149	7.39302e-3	6.54515e-1		Furfural

Figure S4. 49: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 10 (5 mmol), 100 °C, 30 min.



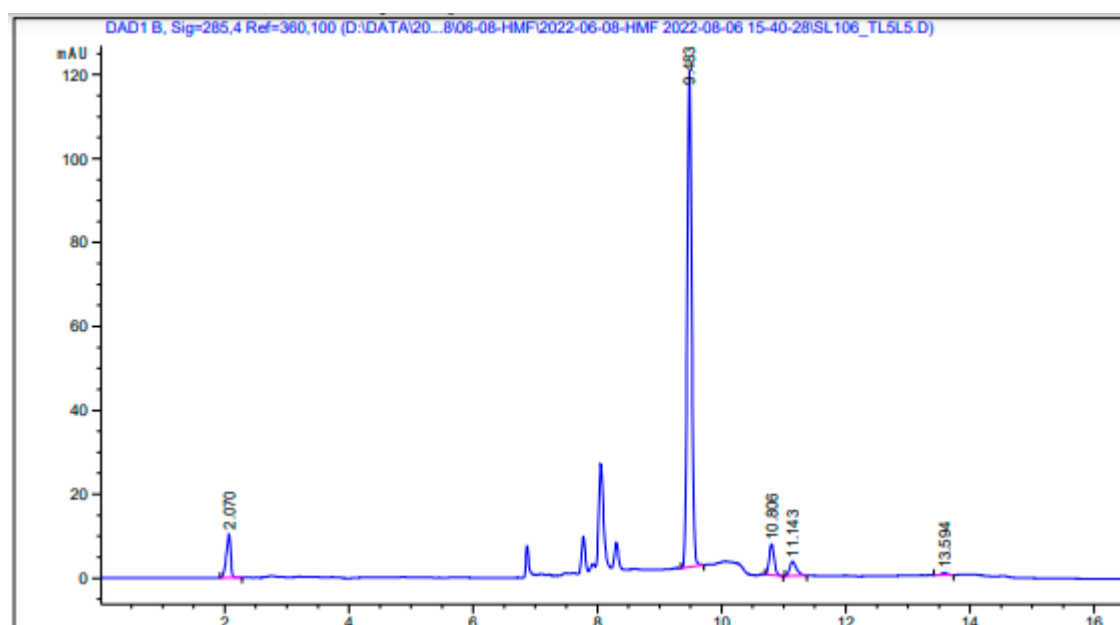
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.686	BV R	339.63965	8.47599e-3	2.87878	-	HMF
10.390	VB E	254.16875	1.16719e-2	2.96663	-	DFF
10.890	BB	17.61457	0.00000	0.00000	-	FDCA
11.397	BB	63.26206	6.26561e-3	3.96375e-1	-	Furfural

Figure S4. 50: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 10 (5 mmol), 100 °C, 60 min.



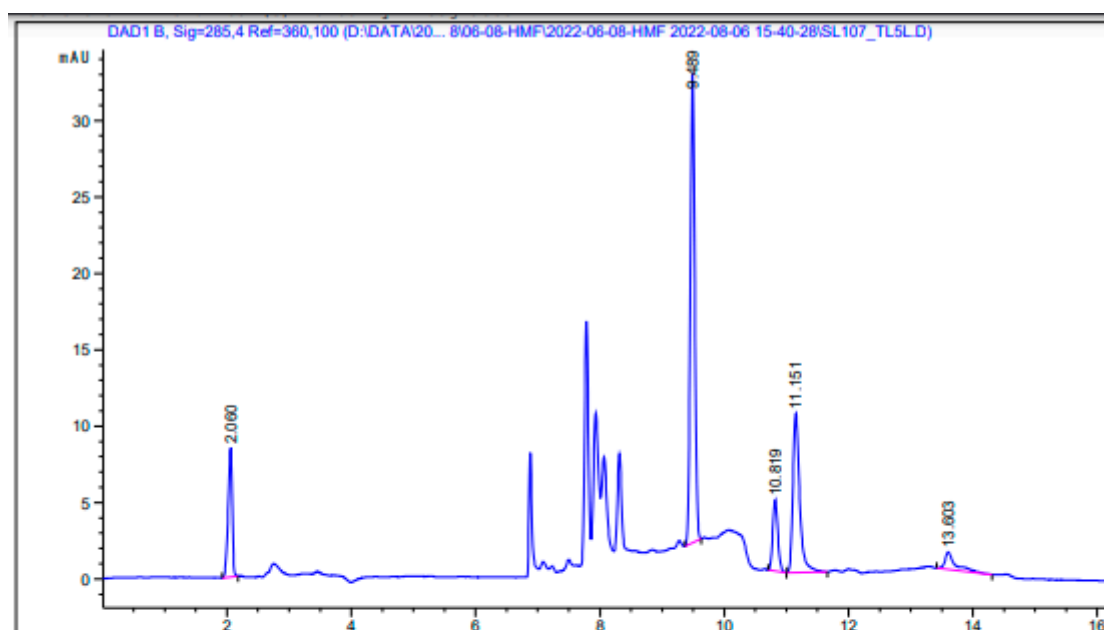
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.483	BB	594.25568	8.97876e-3	5.33568	-	HMF
10.201	-	-	-	-	-	DFF
11.143	BB	25.19542	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 51. HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 11 (5 mmol), 100 °C, 5 min.



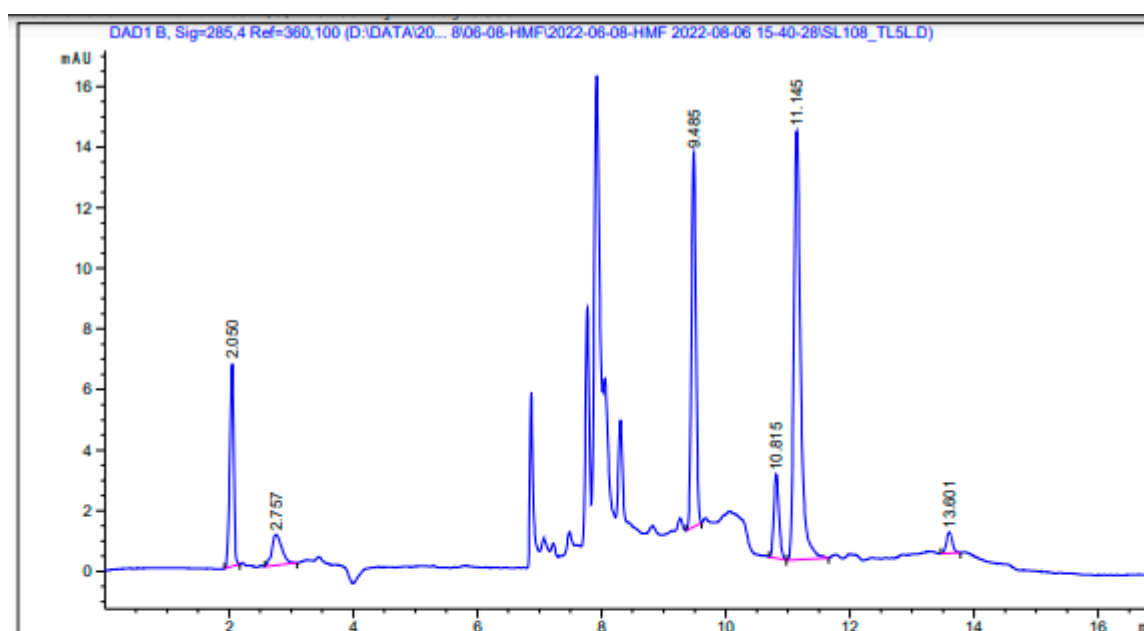
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.489	BB	153.07805	7.04591e-3	1.07857	HMF	
10.201	-	-	-	-	-	DFF
11.151	BB	78.81751	0.00000	0.00000	FDCA	
11.300	-	-	-	-	-	Furfural

Figure S4. 52: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 11 (5 mmol), 100 °C, 10 min.



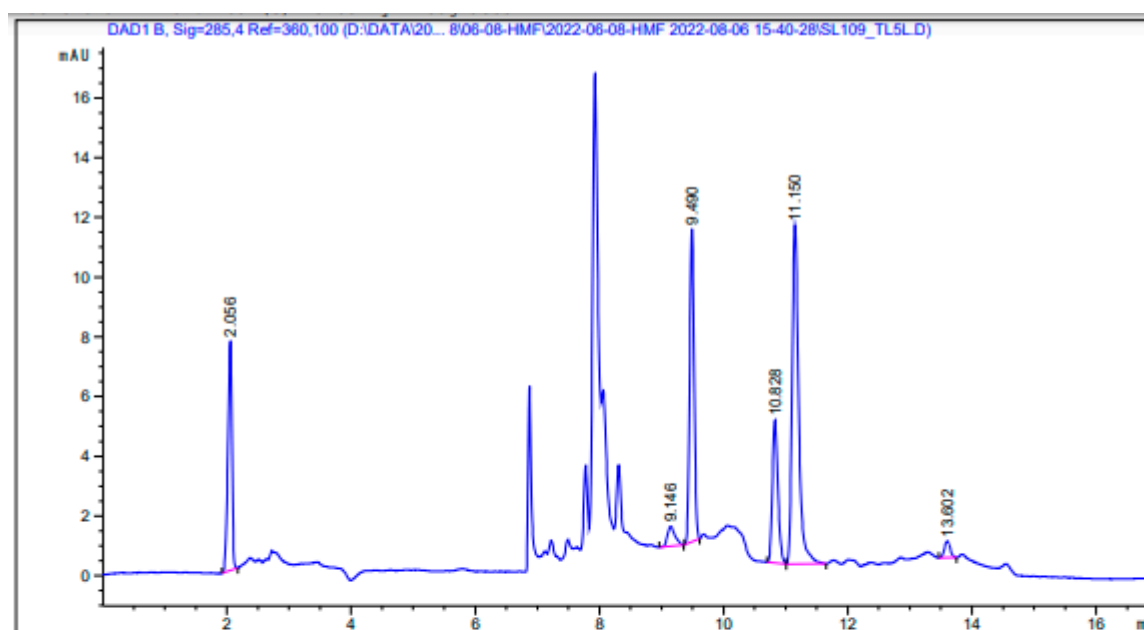
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.485	BB	61.39161	3.15766e-3	1.93854e-1	-	HMF
10.201	-	-	-	-	-	DFF
11.145	BB	105.72366	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 53: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 11 (5 mmol), 100 °C, 20 min.



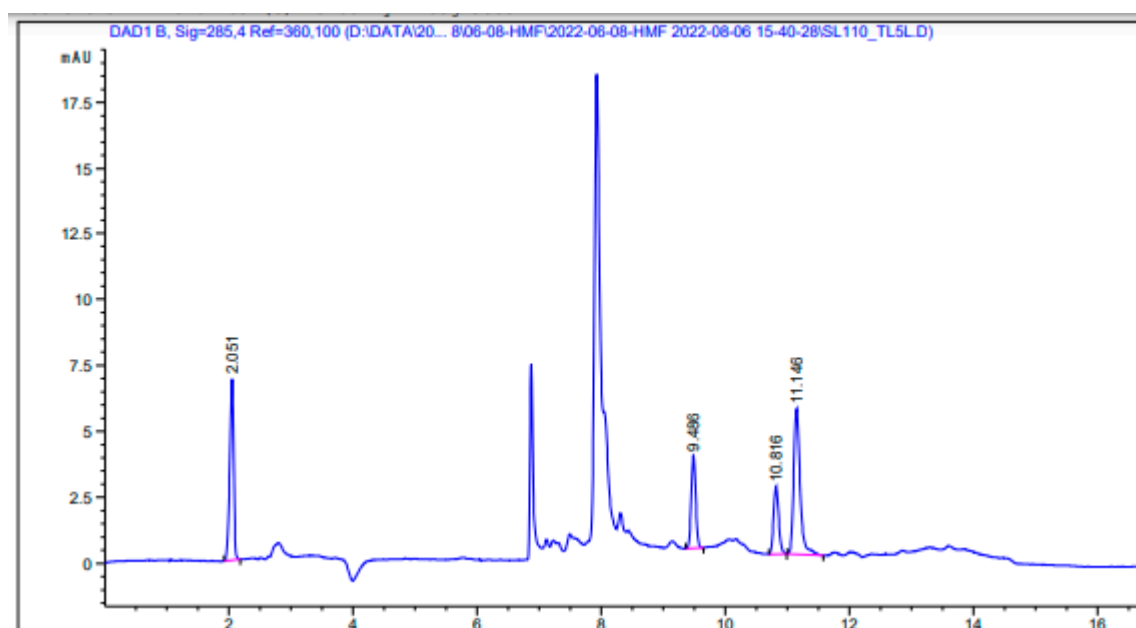
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.490	BB	52.21555	2.01684e-3	1.05310e-1	-	HMF
10.201	-	-	-	-	-	DFF
11.150	BB	82.99045	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 54: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 11 (5 mmol), 100 °C, 30 min.



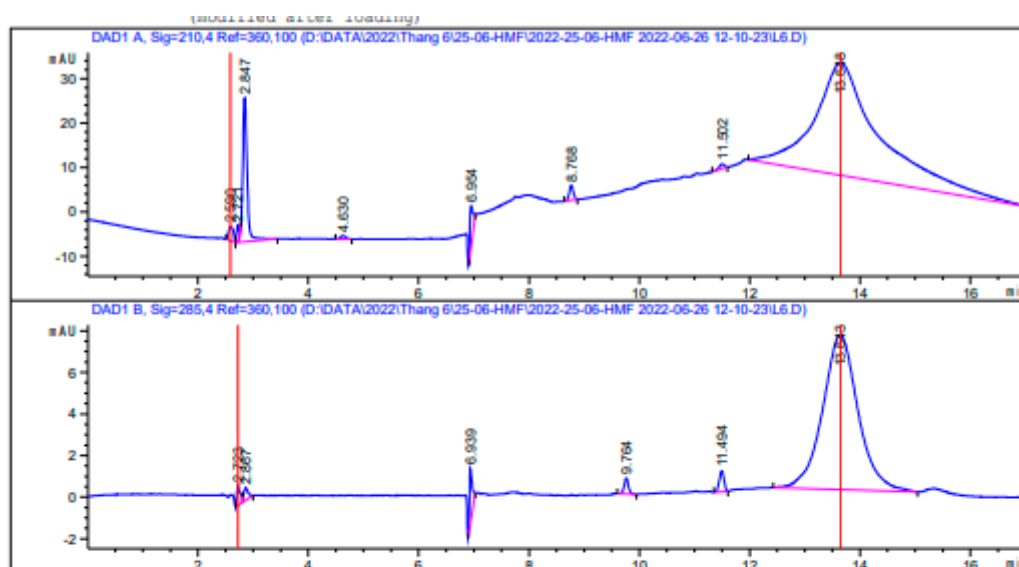
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.486	BB	17.58814	0.00000	0.00000	-	HMF
10.201	-	-	-	-	-	DFF
11.146	BB	39.66236	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 55: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 11 (5 mmol), 100 °C, 60 min.



External Standard Report

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Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Signal 2: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Ant/Area	Amount [ppm]	Grp	Name
8.792	-	-	-	-	-	Levulinic acid
9.764	BB	4.10547	0.00000	0.00000	-	HMF
10.392	-	-	-	-	-	DFF
10.700	-	-	-	-	-	FDCA

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Figure S4. 56: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 12 (5 mmol), 100 °C, 5 min.

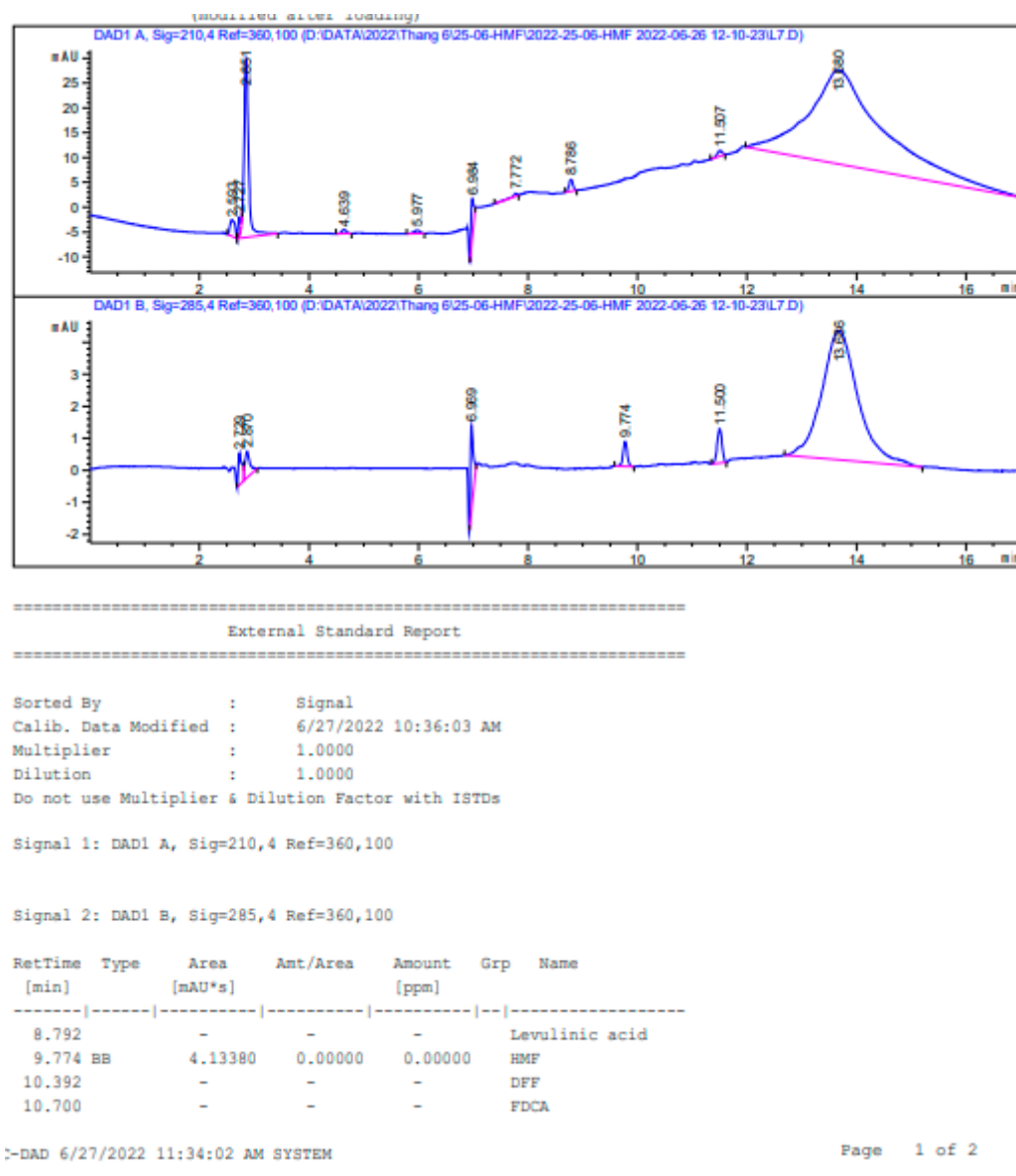
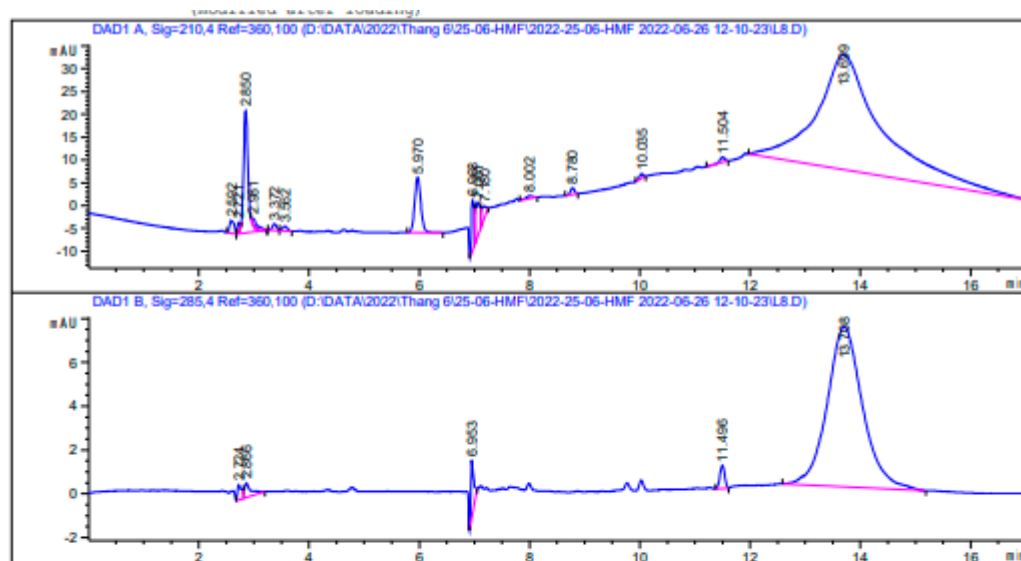


Figure S4. 57: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 12 (5 mmol), 100 °C, 10 min.



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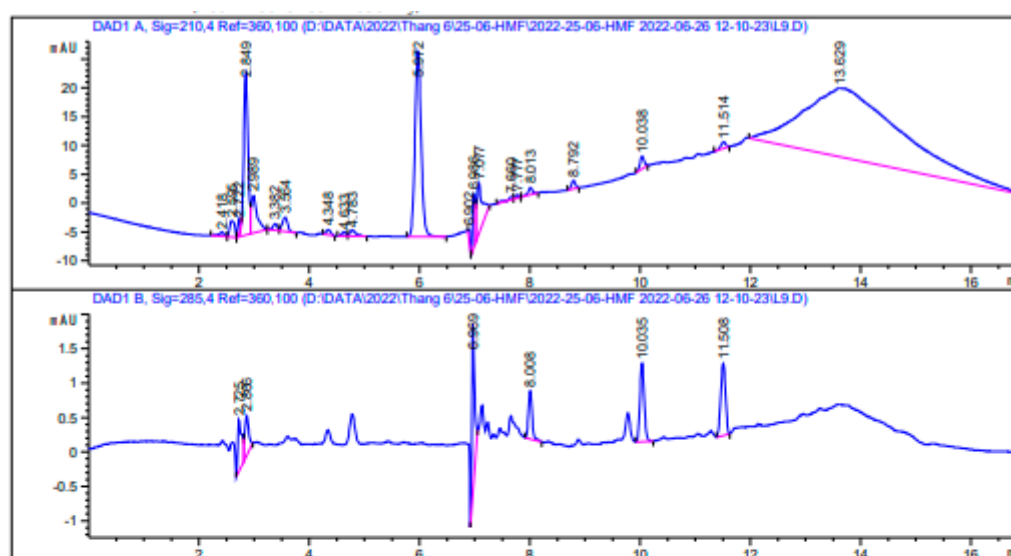
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Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Signal 2: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Ant/Area	Amount [ppm]	Grp	Name
8.792	-	-	-	-	-	Levulinic acid
9.600	-	-	-	-	-	HMF
10.392	-	-	-	-	-	DFF
10.700	-	-	-	-	-	FDCA

Figure S4. 58: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 12 (5 mmol), 100 °C, 20 min.



External Standard Report

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Signal 1: DAD1 A, Sig=210,4 Ref=360,100

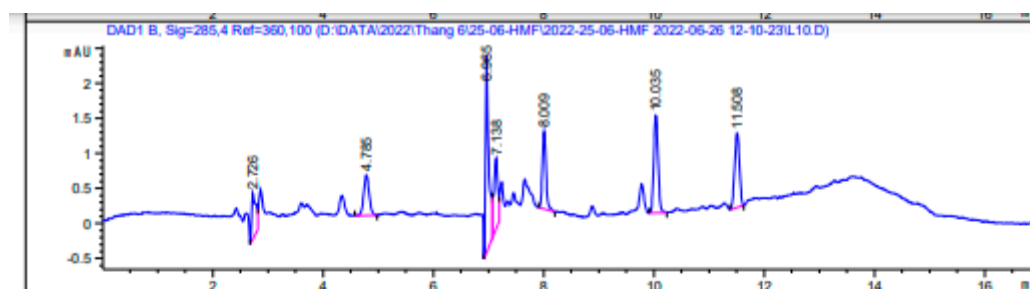
Signal 2: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Ant/Area	Amount [ppm]	Grp	Name
8.792	-	-	-	-	-	Levulinic acid
9.600	-	-	-	-	-	HMF
10.392	-	-	-	-	-	DFF
10.700	-	-	-	-	-	FDCA

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Figure S4. 59: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 12 (5 mmol), 100 °C, 30 min.



External Standard Report

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 Dilution : 1.0000
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Signal 1: DAD1 A, Sig=210,4 Ref=360,100

Signal 2: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.792	-	-	-	-	-	Levulinic acid
9.600	-	-	-	-	-	HMF
10.392	-	-	-	-	-	DFF
10.700	-	-	-	-	-	FDCA

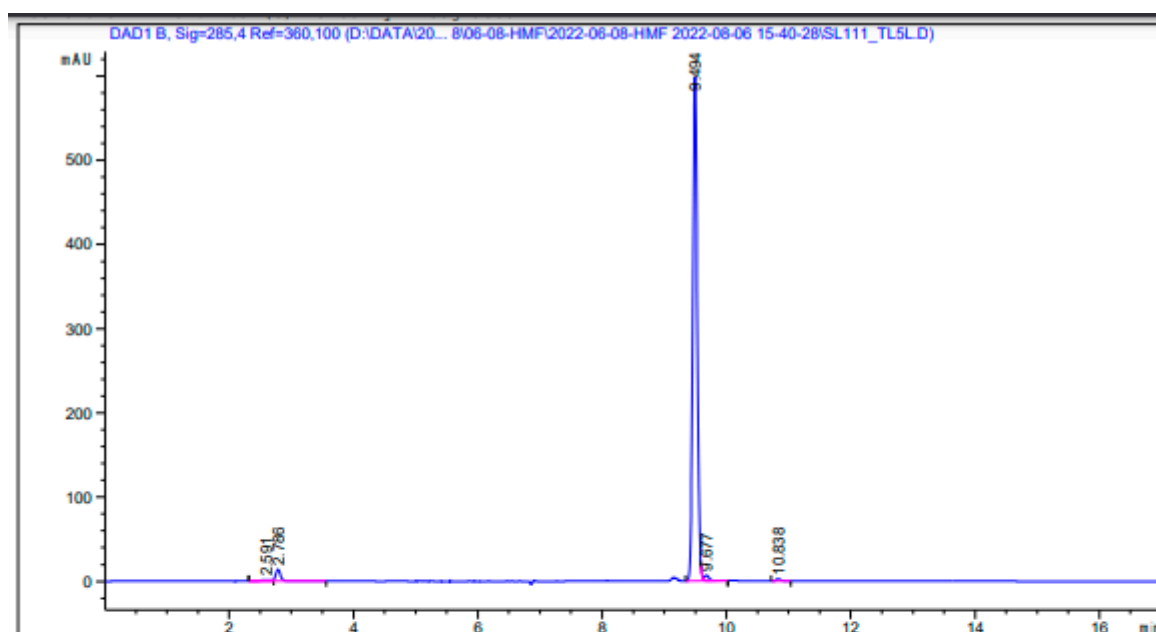
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File D:\DATA\2022\Thang 6\25-06-HMF\2022-25-06-HMF 2022-06-26 12-10-23\L10.D
 Sample Name: L10

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Totals :				0.00000		

Figure S4. 60: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 12 (5 mmol), 100 °C, 60 min.



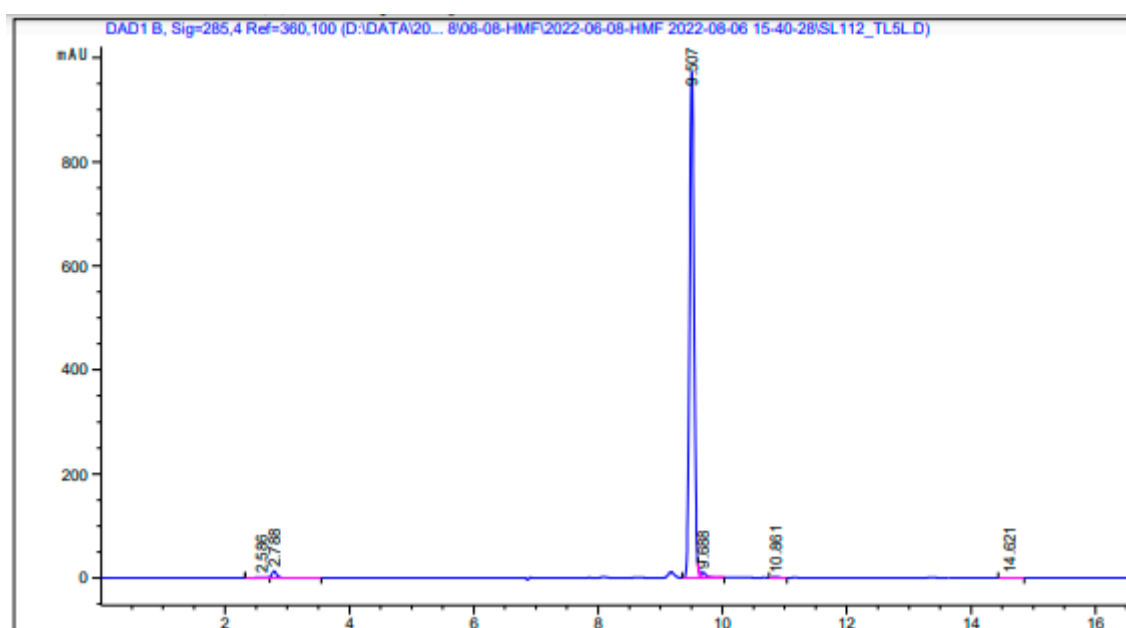
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.677	VB E	40.98586	0.00000	0.00000	-	HMF
10.201	-	-	-	-	-	DFF
10.838	BB	13.56850	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 61: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 80 °C, 5 min.



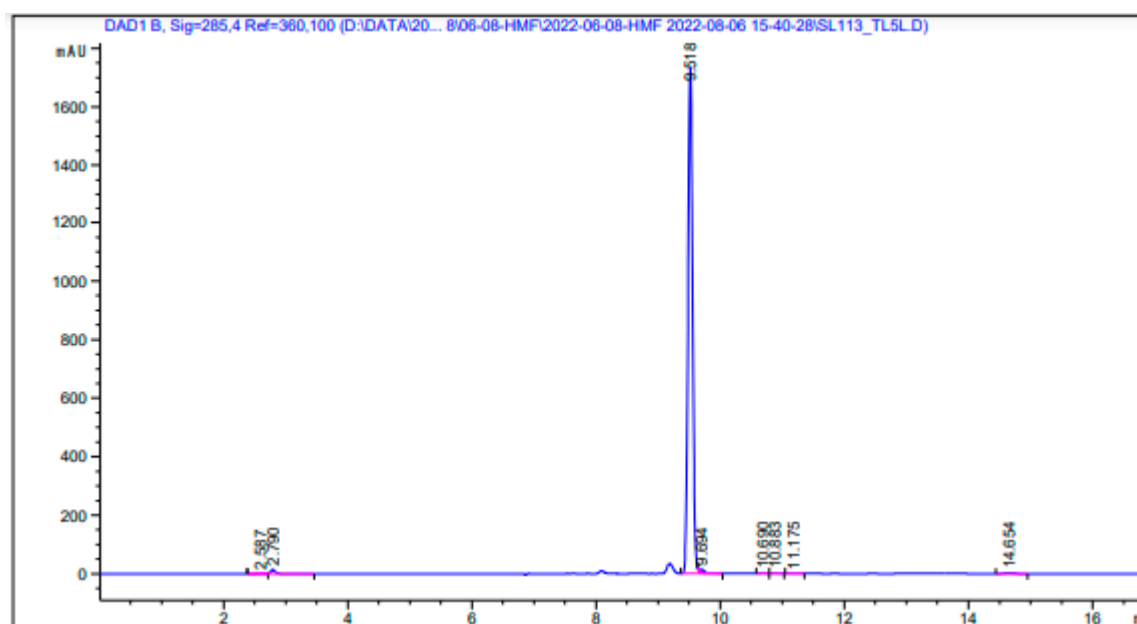
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.688	VB E	61.27998	3.14584e-3	1.92777e-1	-	HMF
10.201	-	-	-	-	-	DFF
10.861	BB	10.99834	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 62: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 80 °C, 10 min.



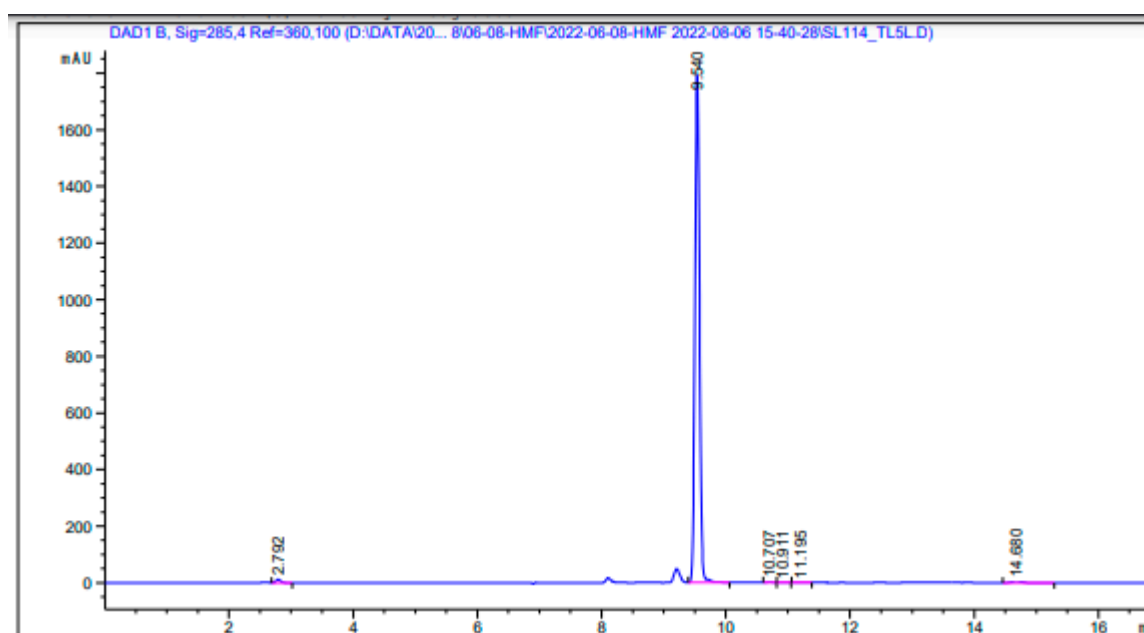
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.518	BV R	8820.30273	9.60423e-3	84.71217	-	HMF
10.201	-	-	-	-	-	DFF
11.175	BB	6.42345	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 63: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 80 °C, 20 min.



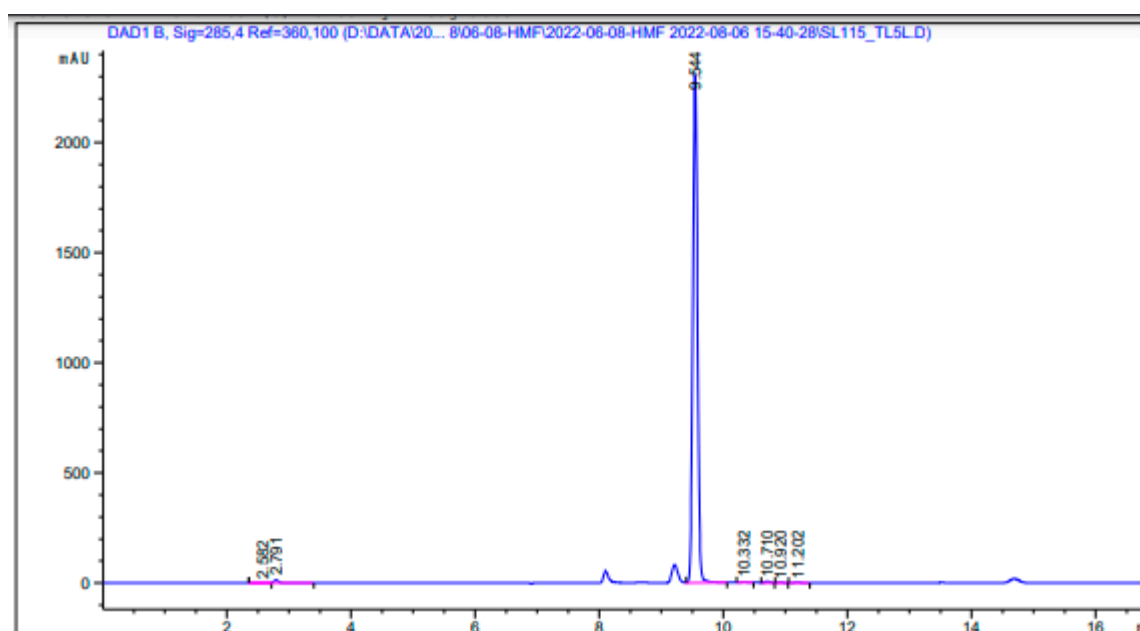
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.540	BB	9224.59961	9.60621e-3	88.61340	-	HMF
10.201	-	-	-	-	-	DFF
11.195	BB	6.93750	0.00000	0.00000	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 64: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 1 (5 mmol), 80 °C, 30 min.



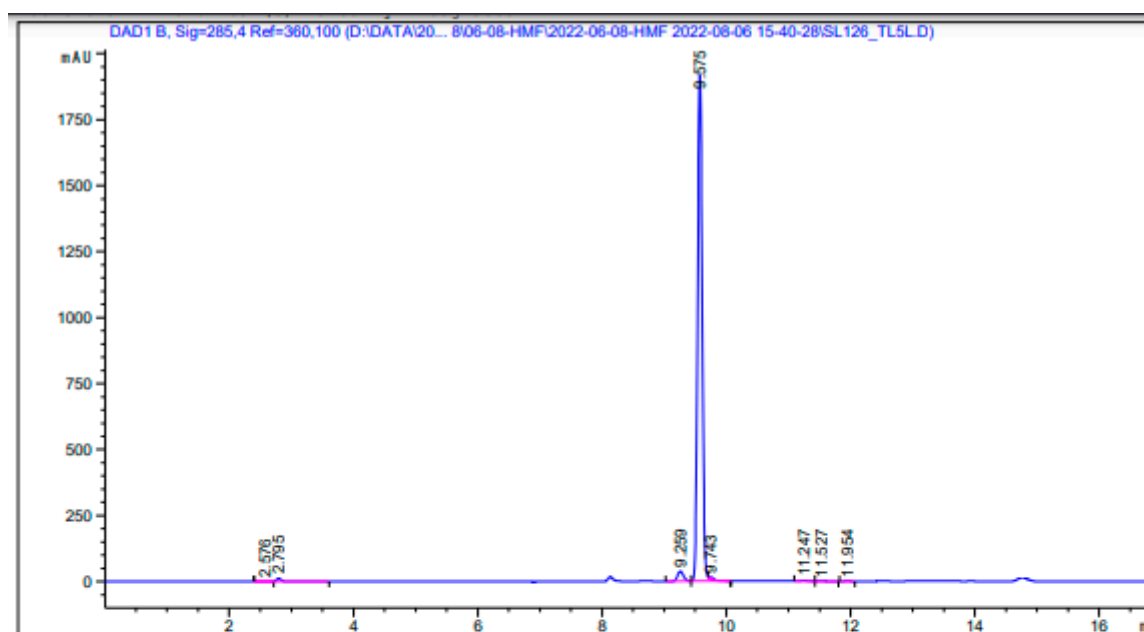
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.544	VB	1.20805e4	9.61642e-3	116.17151		HMF
10.332	BB	14.73751	3.23053e-2	4.76100e-1		DFF
10.920	BB	5.54461	0.00000	0.00000		FDCA
11.202	BB	7.82974	0.00000	0.00000		Furfural

Figure S4. 65: HPLC chromatography of HMF. Reaction condntion: Fructose (1 mmol), DES 1 (5 mmol), 80 °C, 60 min.



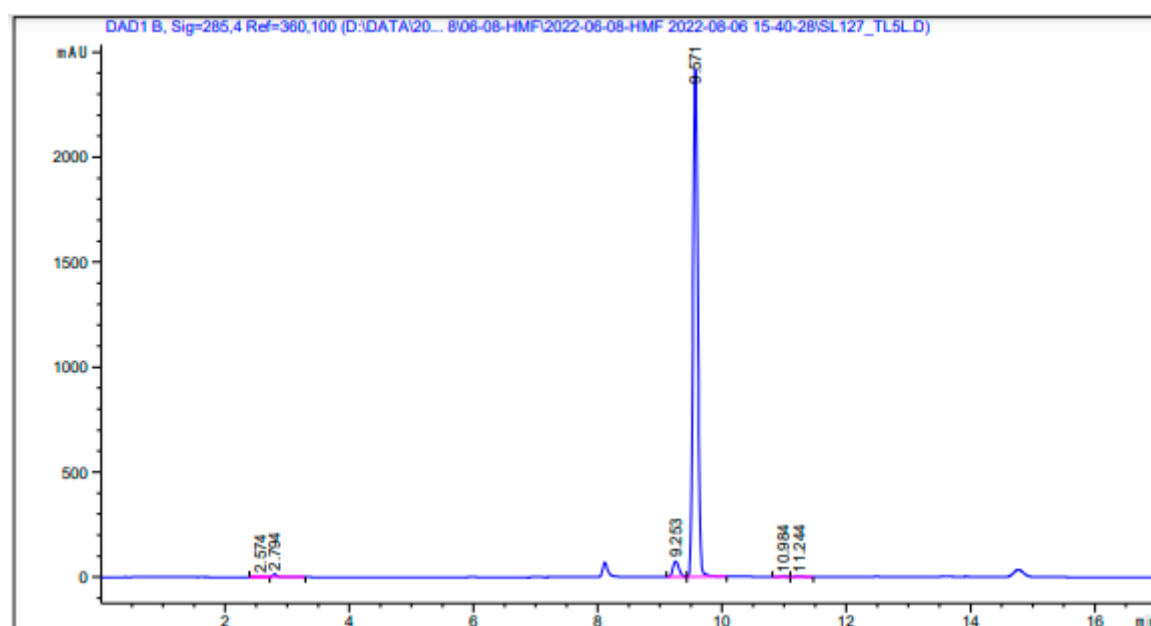
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.575	VV R	9920.37988	9.60924e-3	95.32727	HMF	
10.201	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.247	BV	19.35286	0.00000	0.00000	Furfural	

Figure S4. 66: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 120 °C, 5 min.



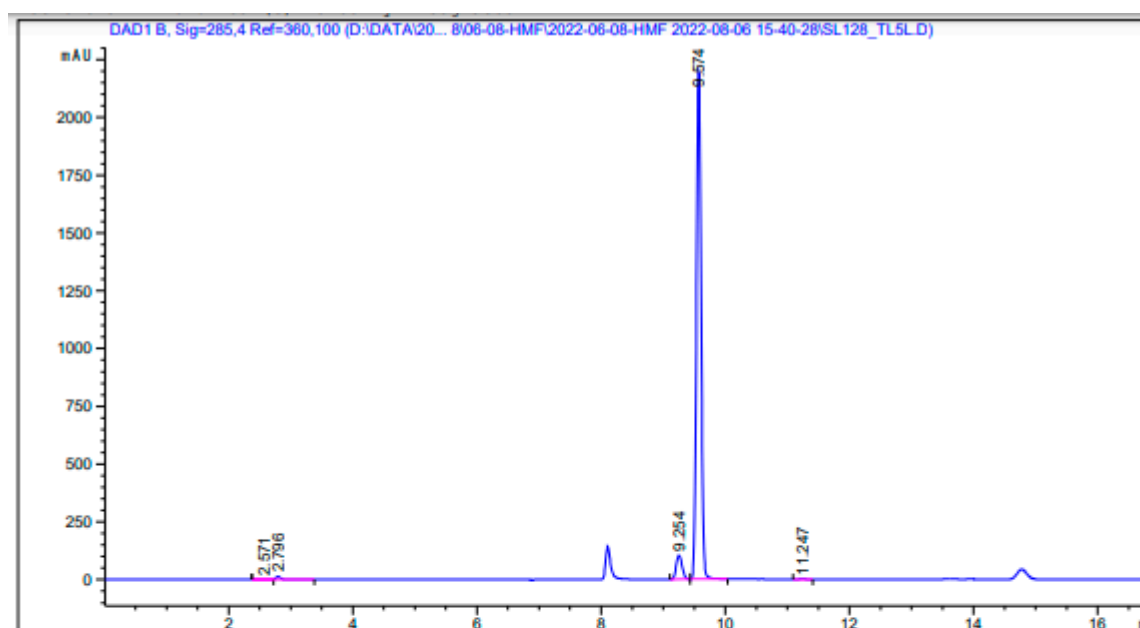
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 Dilution : 1.0000
 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.571	VB	1.28694e4	9.61844e-3	123.78348	-	HMF
10.201	-	-	-	-	-	DFF
10.984	BV	13.60453	0.00000	0.00000	-	FDCA
11.244	VB	19.63445	0.00000	0.00000	-	Furfural

Figure S4. 67: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 120 °C, 10 min.



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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.574	BB	1.14555e4	9.61462e-3	110.14074	HMF	
10.201	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.247	BB	11.02428	0.00000	0.00000	Furfural	

Figure S4. 68: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 120 °C, 20 min.

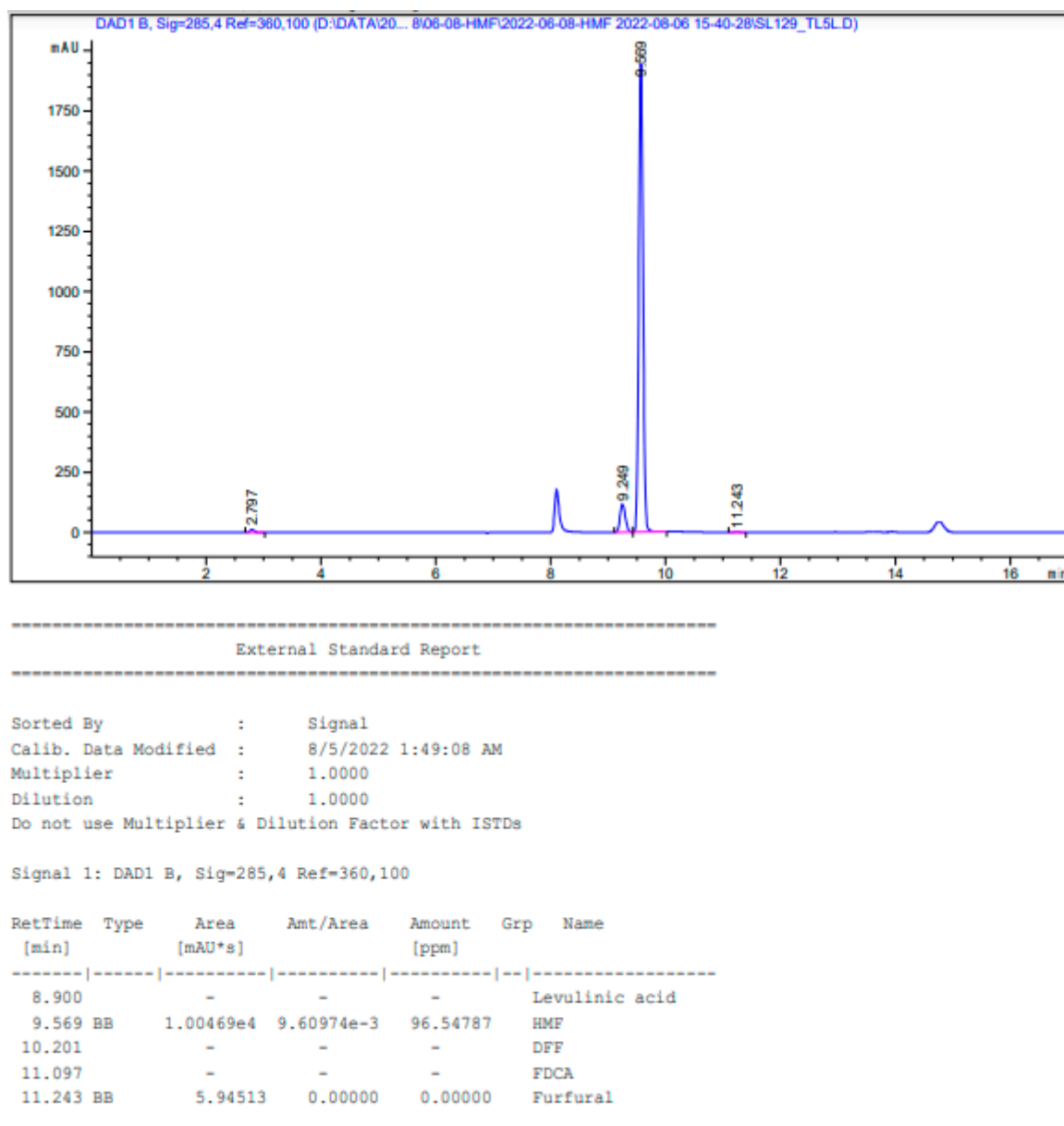
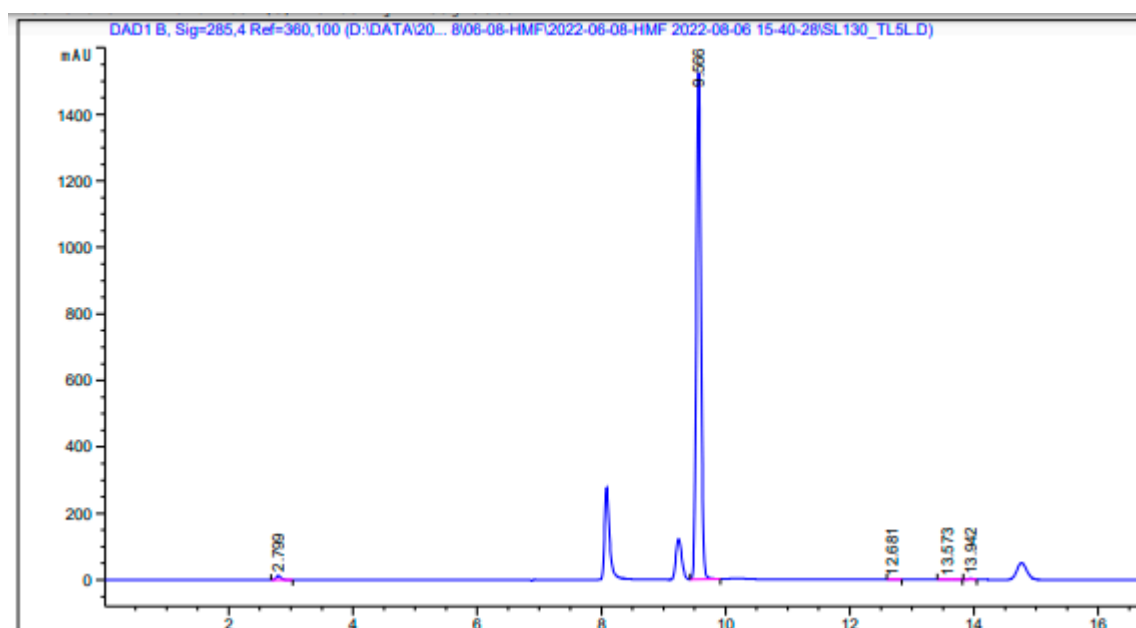


Figure S4. 69: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 120 °C, 30 min.



External Standard Report

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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.566	BB	7798.87598	9.59831e-3	74.85601	-	HMF
10.201	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 70: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (5 mmol), 120 °C, 60 min.

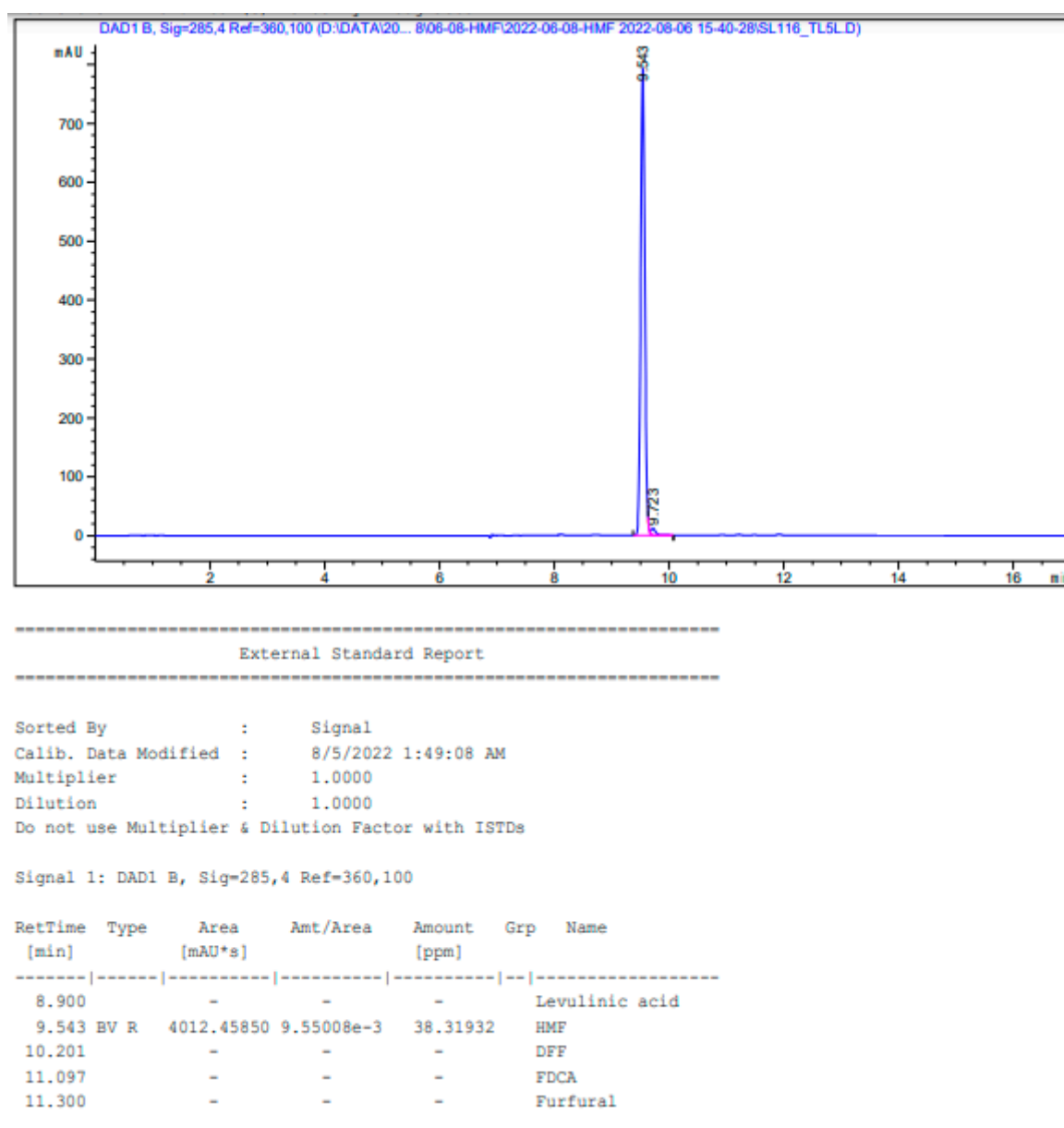
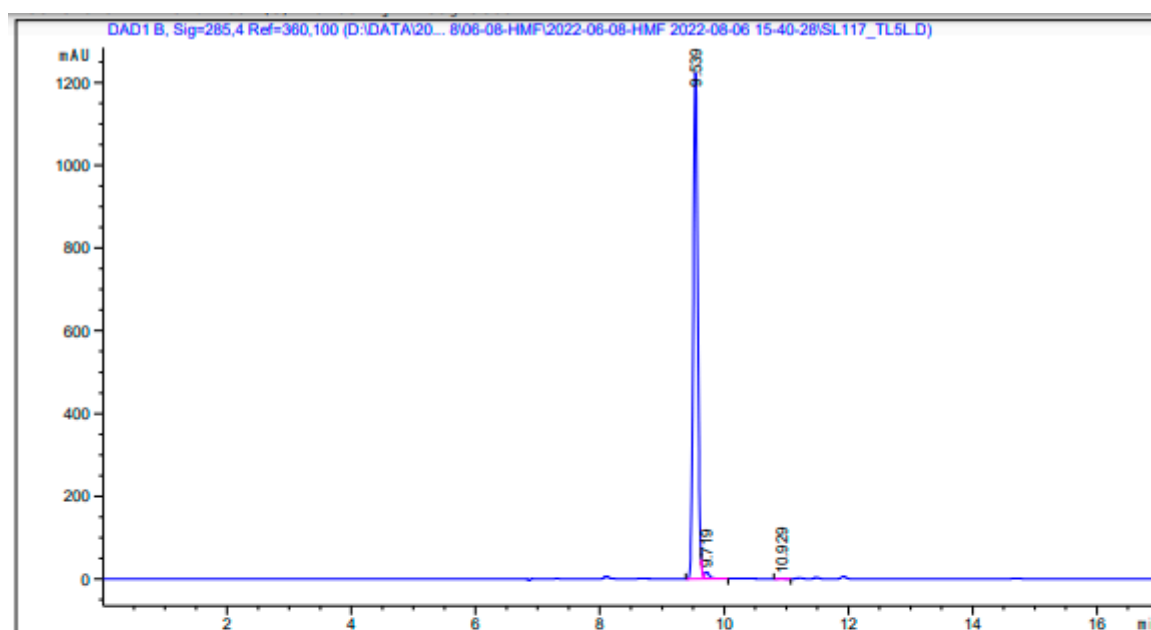


Figure S4. 71: HPLC chromatography of HMF. Reaction condtion: Fructose (1 mmol), DES 2 (5 mmol), 80 °C, 5 min.



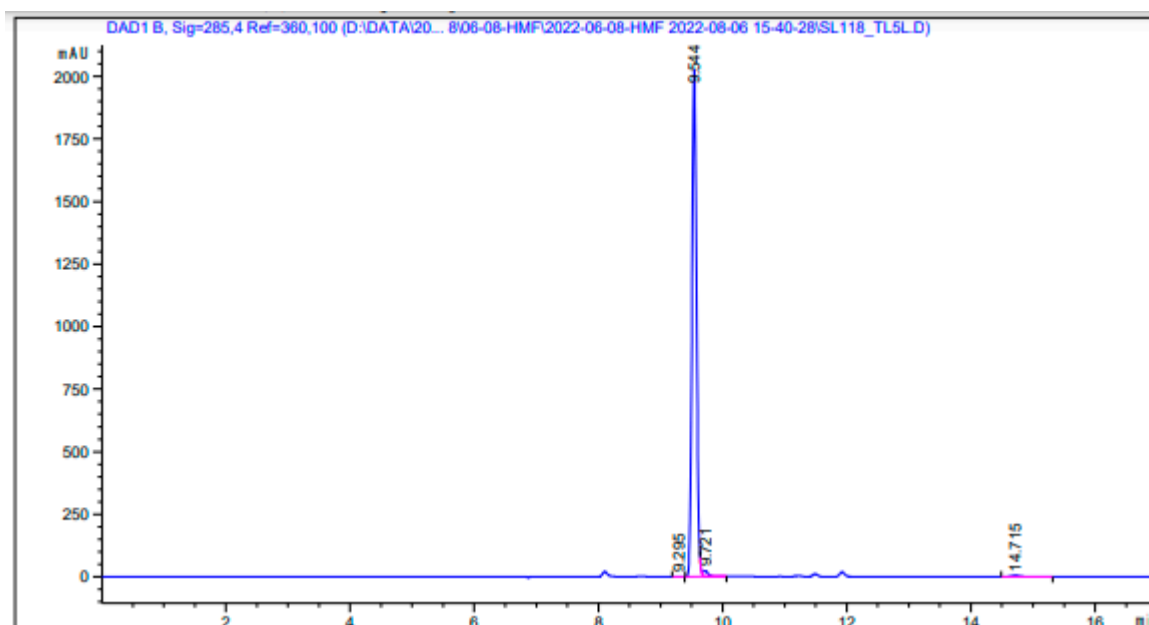
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.539	BV R	6218.55078	9.58532e-3	59.60680	HMF	
10.201	-	-	-	-	-	DFF
10.929	BB	5.39169	0.00000	0.00000	FDCA	
11.300	-	-	-	-	-	Furfural

Figure S4. 72: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 80 °C, 10 min.



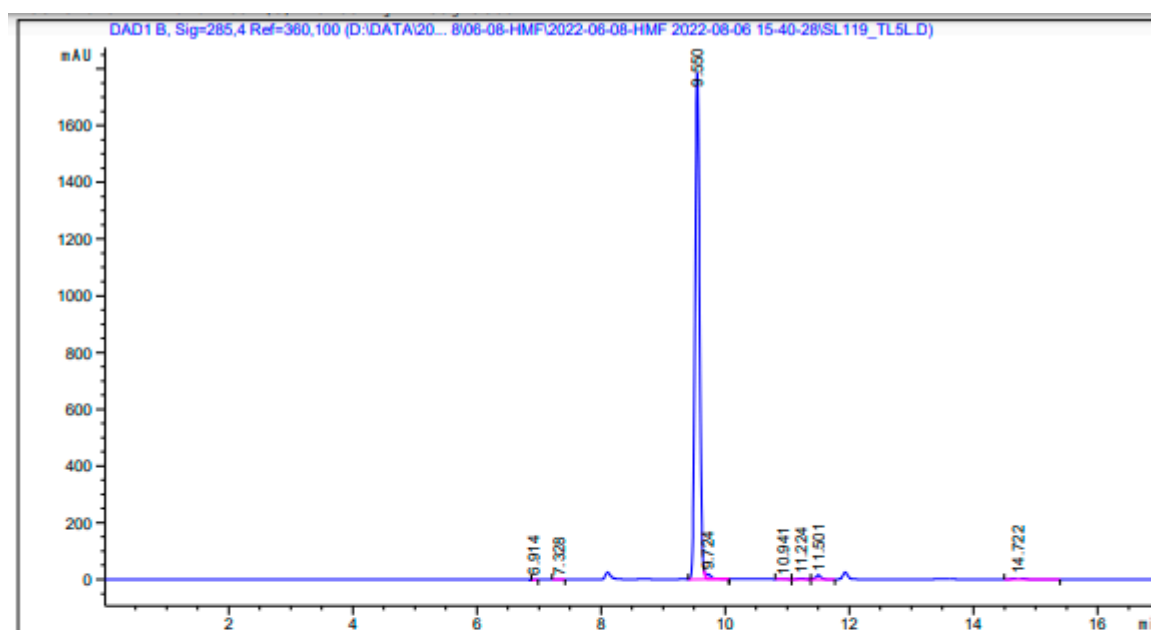
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 Dilution : 1.0000
 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.544	BV R	1.03861e4	9.61104e-3	99.82160	-	HMF
10.201	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.300	-	-	-	-	-	Furfural

Figure S4. 73: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 80 °C, 20 min.



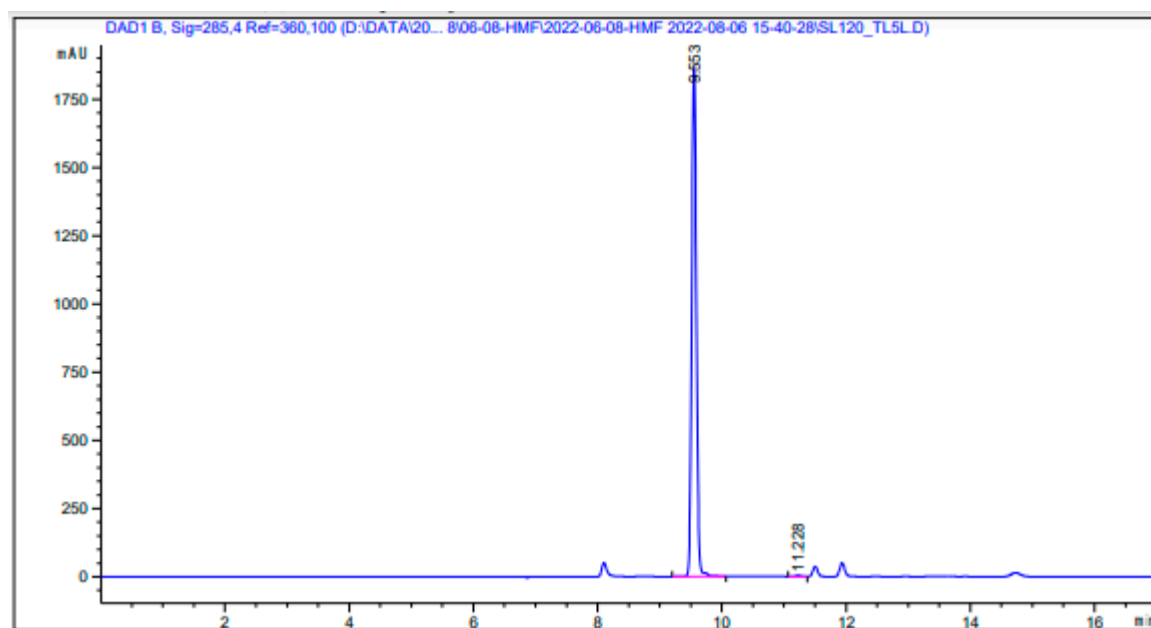
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.550	VV R	9129.35352	9.60575e-3	87.69433	HMF	
10.201	-	-	-	-	-	DFF
10.941	BB	4.96607	0.00000	0.00000	FDCA	
11.224	BV	22.69624	0.00000	0.00000	Furfural	

Figure S4. 74: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 80 °C, 30 min.



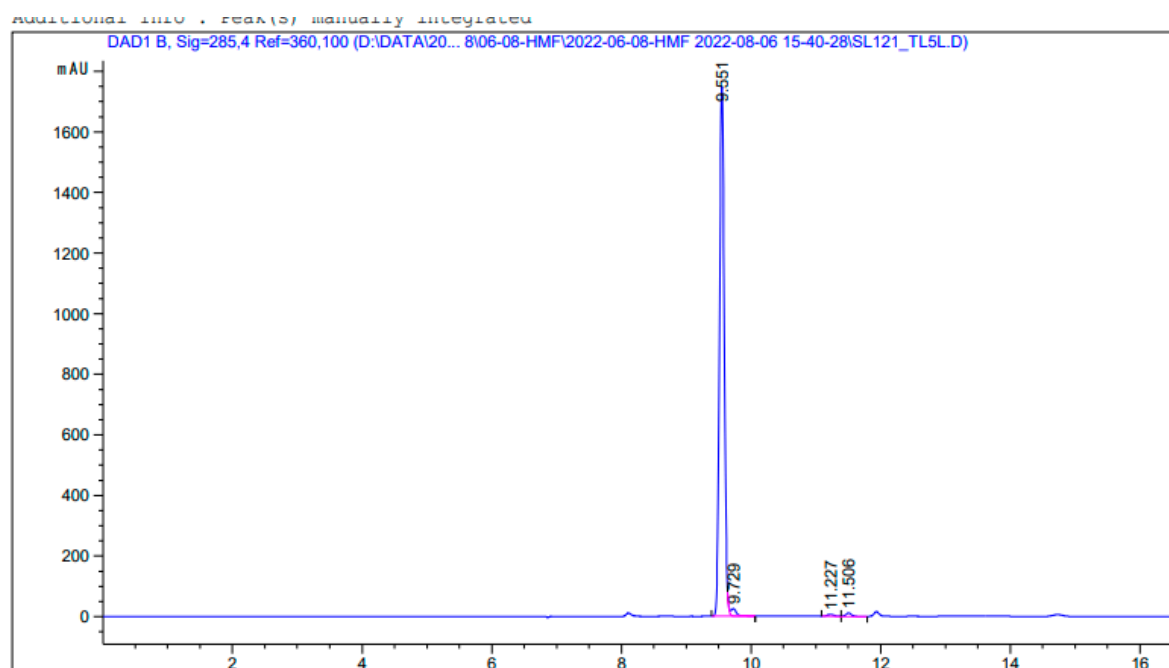
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.553	VB R	9647.13867	9.60810e-3	92.69065		HMF
10.201		-	-	-		DFF
11.097		-	-	-		FDCA
11.228	BV	26.73737	8.69838e-4	2.32572e-2		Furfural

Figure S4. 75: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 80 °C, 60 min.



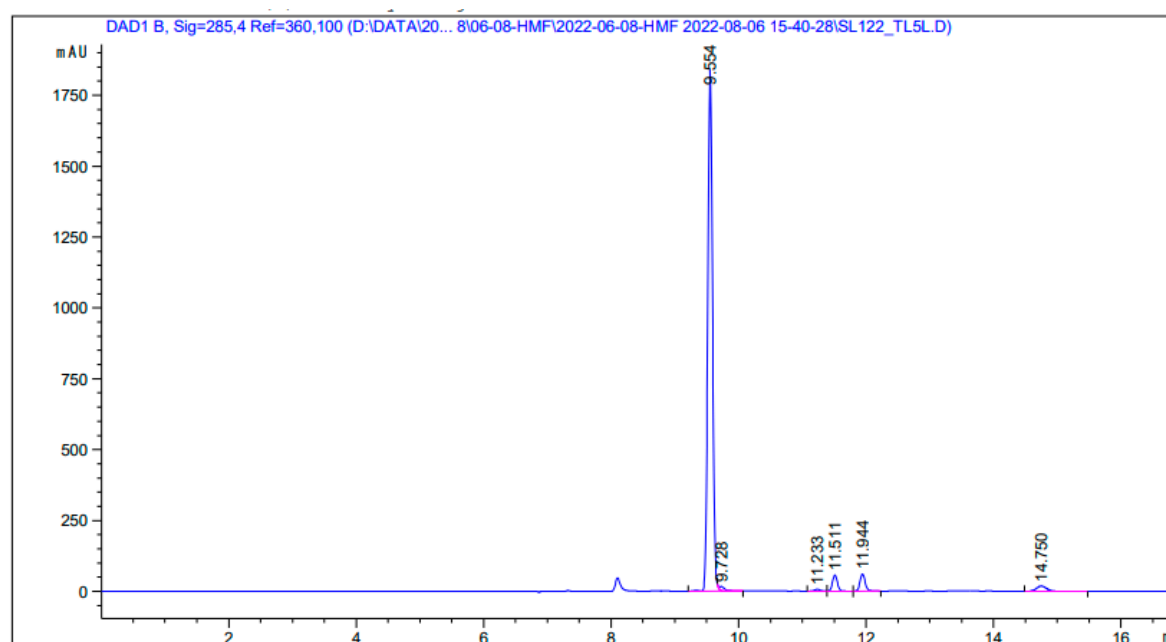
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.551	VV R	8978.54102	9.60502e-3	86.23908	-	HMF
10.201	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.227	BV	45.71900	4.74997e-3	2.17164e-1	-	Furfural

Figure S4. 76: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 120 °C, 5 min.



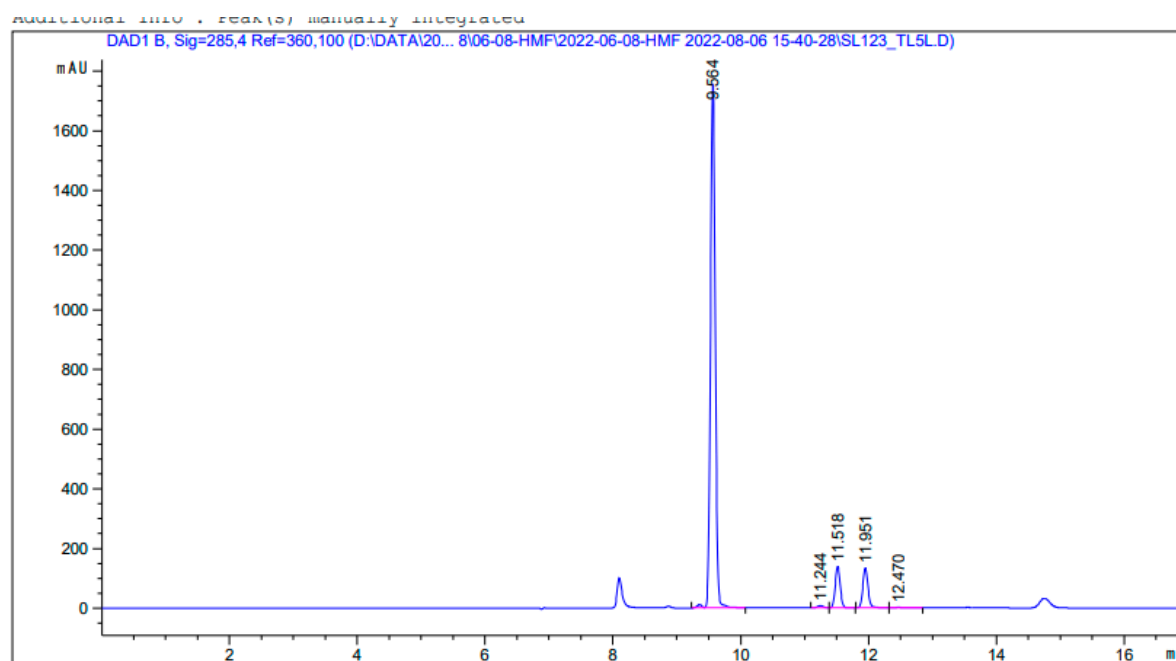
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.554	VV R	9461.81055	9.60729e-3	90.90234		HMF
10.201		-	-	-		DFF
11.097		-	-	-		FDCA
11.233	BV	41.30664	4.16615e-3	1.72090e-1		Furfural

Figure S4. 77: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 120 °C, 10 min.



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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.564	VB R	9100.50293	9.60562e-3	87.41594	-	HMF
10.201	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.244	BV	48.74539	5.08930e-3	2.48080e-1	-	Furfural

Figure S4. 78: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 120 °C, 20 min.

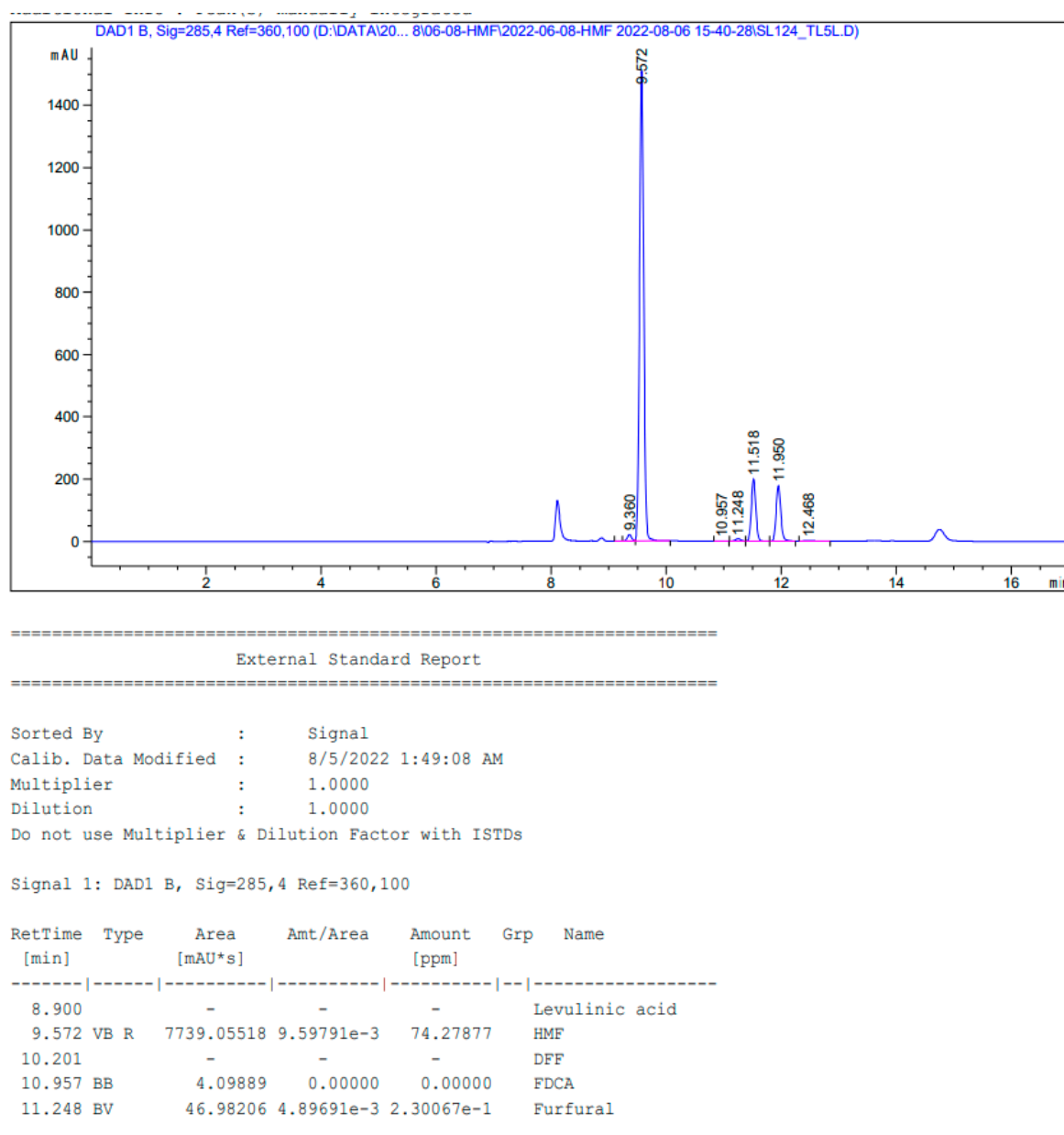
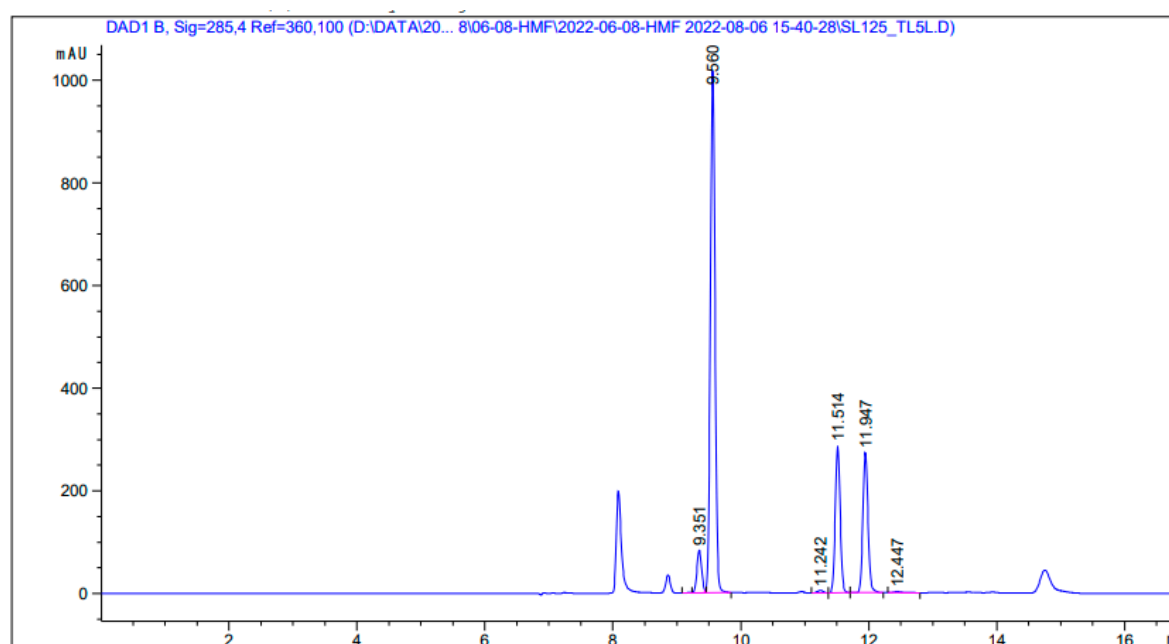


Figure S4. 79: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 120 °C, 30 min.



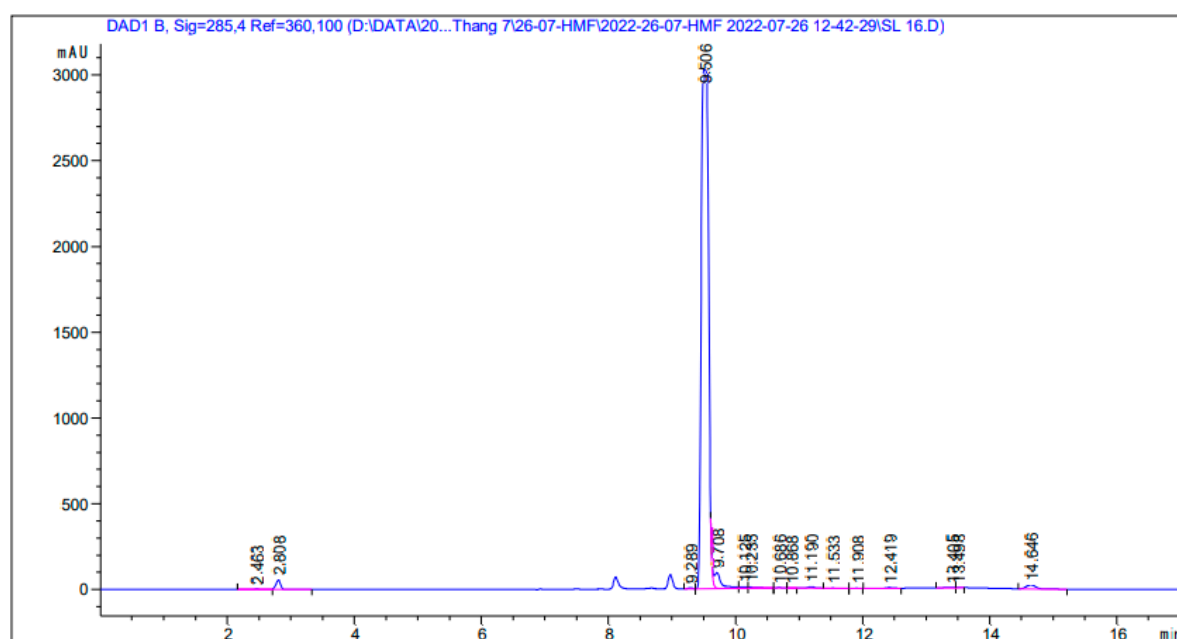
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.560	VB R	5204.16455	9.57283e-3	49.81857	-	HMF
10.201	-	-	-	-	-	DFF
11.097	-	-	-	-	-	FDCA
11.242	BB	30.24692	1.95422e-3	5.91090e-2	-	Furfural

Figure S4. 80: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 2 (5 mmol), 120 °C, 60 min.



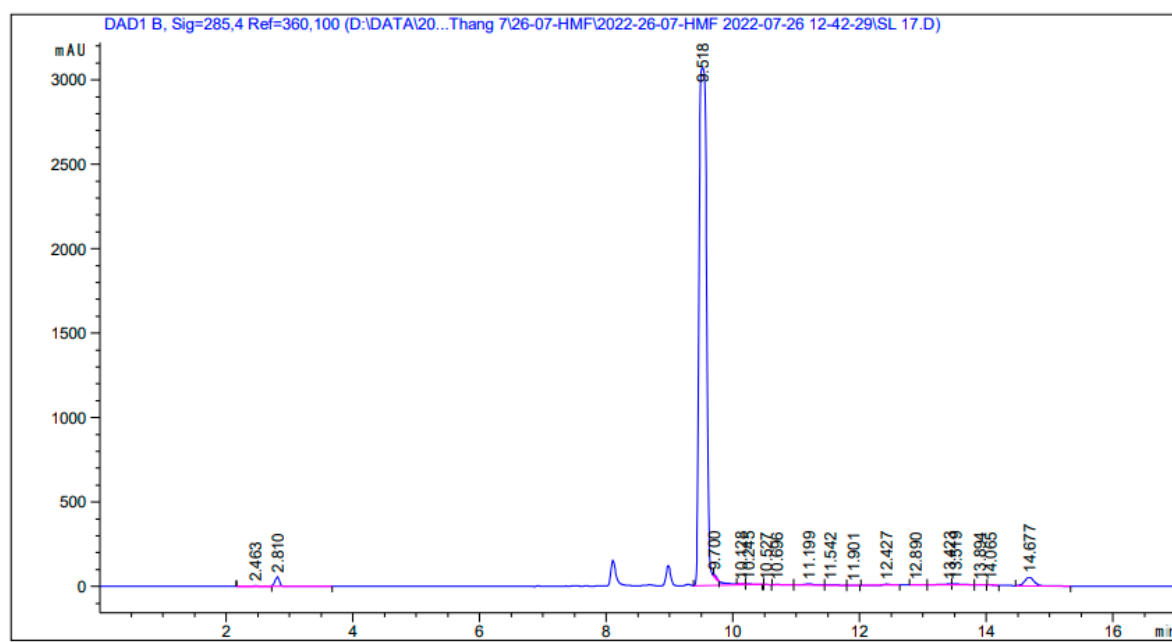
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.506	BV R	2.41710e4	9.63292e-3	232.83735		HMF
10.686	BV	13.37472	3.45371e-2	4.61925e-1		DFF
11.190	VV R	67.00442	0.00000	0.00000		FDCA
11.533	VV E	12.37573	0.00000	0.00000		Furfural

Figure S4. 81: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (1 mmol), 100 °C, 5 min.



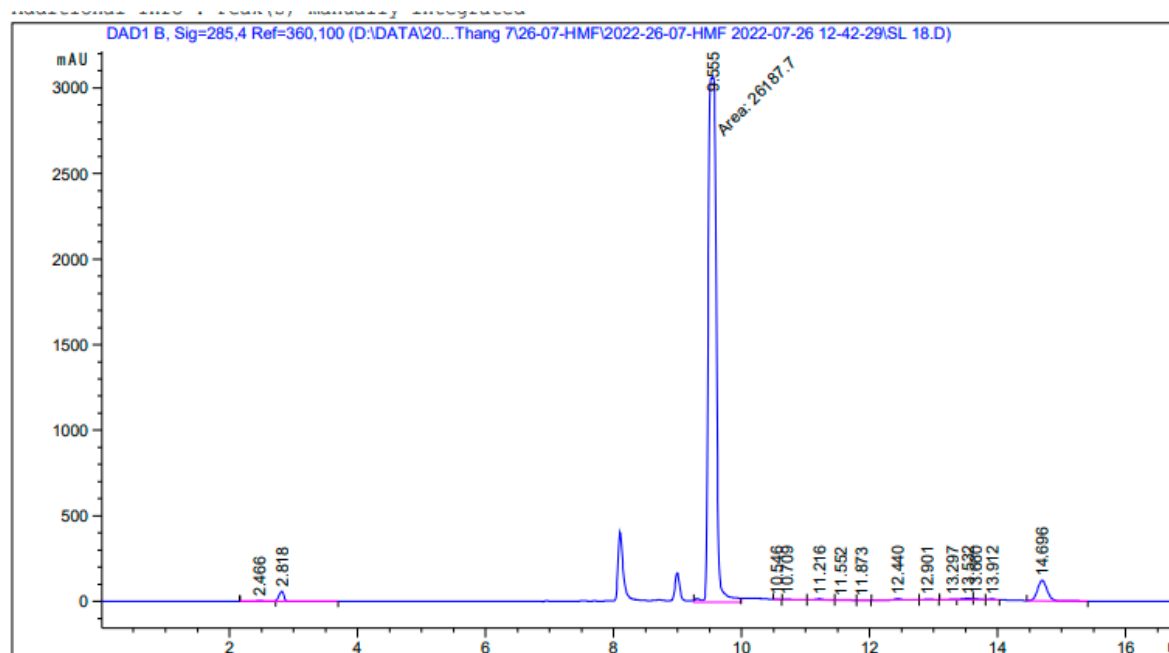
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 Dilution : 1.0000
 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.518	BV R	2.52909e4	9.63365e-3	243.64371	-	HMF
10.527	BB	2.67788	1.30946e-1	3.50658e-1	-	DFF
11.097	-	-	-	-	-	FDCA
11.199	BV	68.98654	6.59337e-3	4.54854e-1	-	Furfural

Figure S4. 82: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (1 mmol), 100 °C, 10 min.



External Standard Report

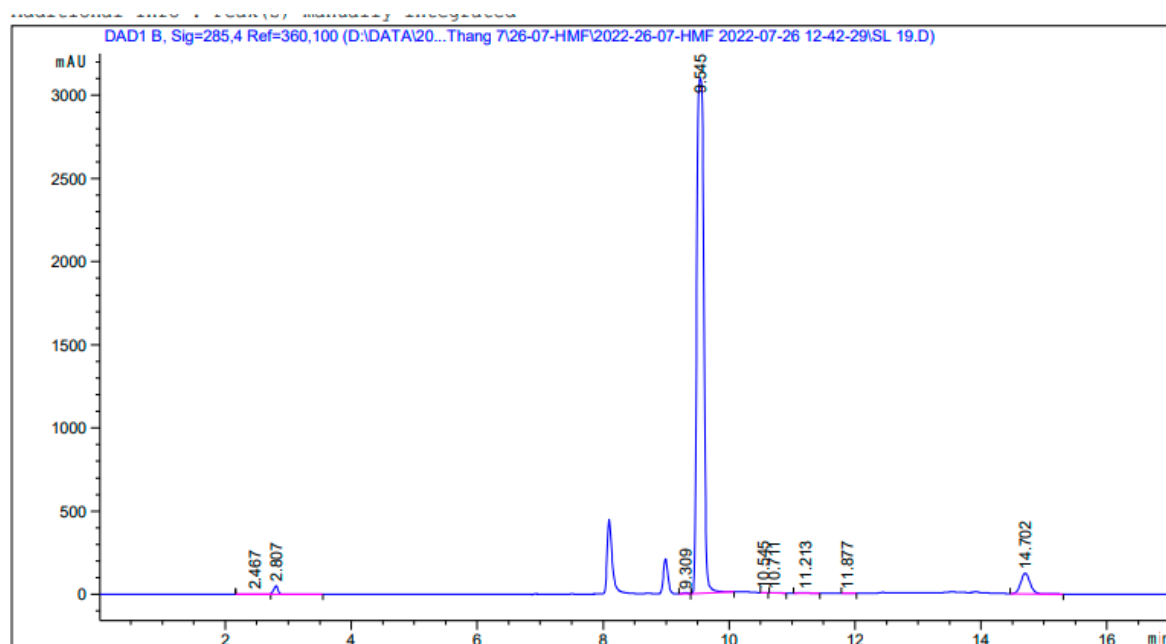
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.555	MM	2.61877e4	9.63419e-3	252.29744		HMF
10.546	BB	5.05104	7.43100e-2	3.75343e-1		DFF
11.097		-	-	-		FDCA
11.216	VV	57.56285	5.87453e-3	3.38155e-1		Furfural

Totals : 253.01094

Figure S4. 83: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (1 mmol), 100 °C, 20 min.



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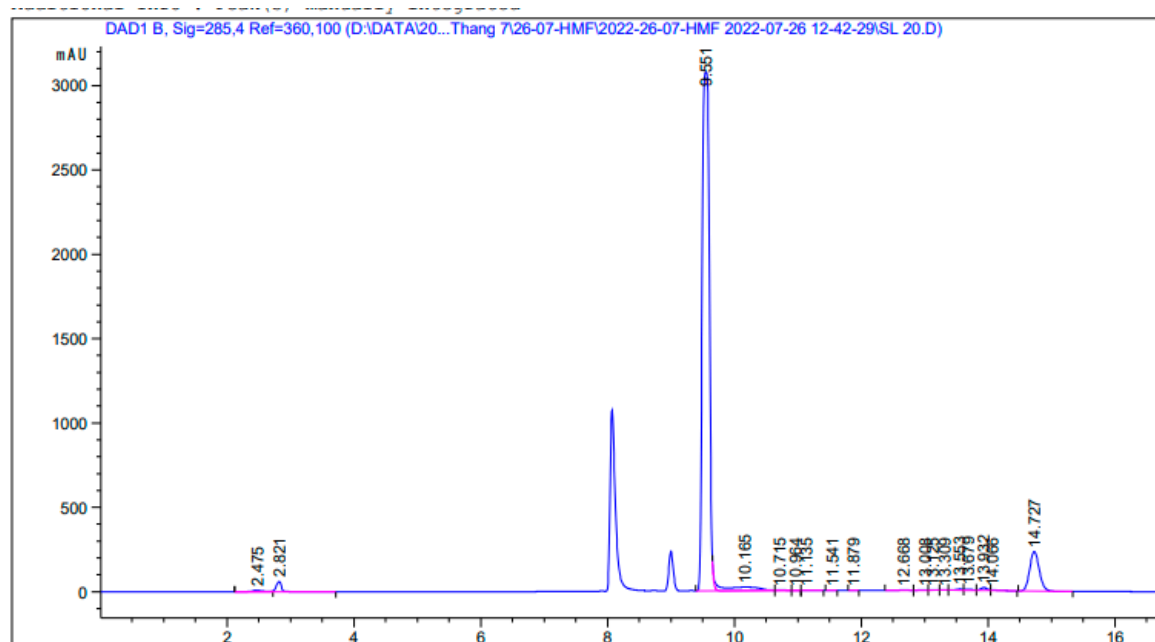
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.545	BB	2.35692e4	9.63250e-3	227.03012		HMF
10.545	BB	3.55043	1.01321e-1	3.59734e-1		DFF
11.097		-	-	-		FDCA
11.213	BB	25.36020	3.62330e-4	9.18877e-3		Furfural

Totals : 227.39904

Figure S4. 84: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (1 mmol), 100 °C, 30 min.



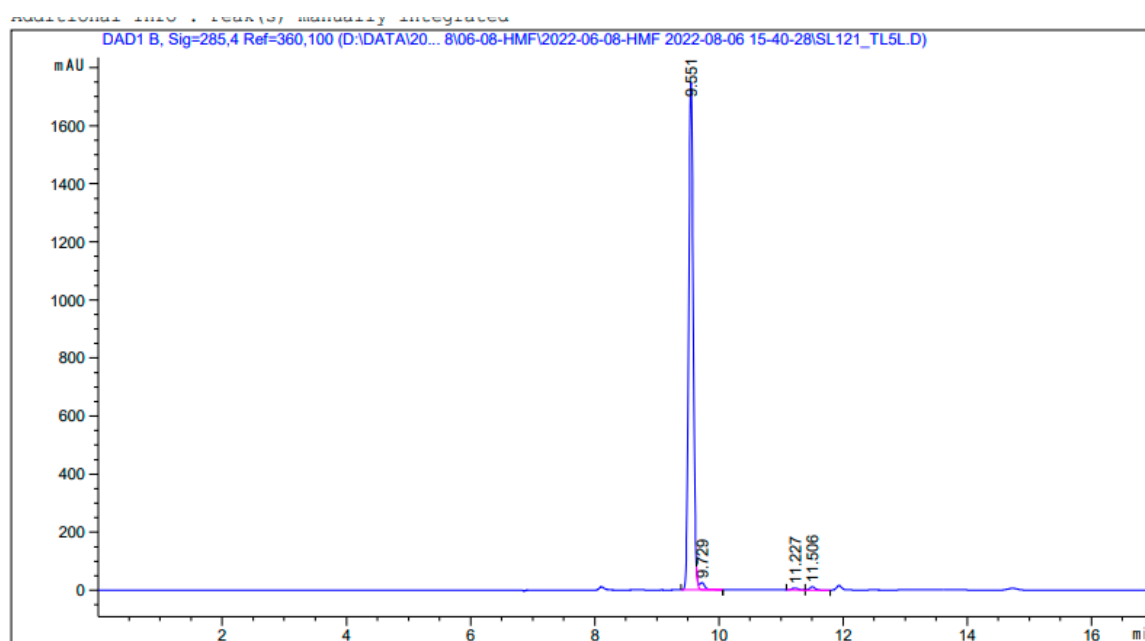
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900	-	-	-	-	-	Levulinic acid
9.551	BV R	2.35853e4	9.63251e-3	227.18598	-	HMF
10.715	VV E	32.72031	2.02674e-2	6.63155e-1	-	DFF
11.135	BB	12.04596	0.00000	0.00000	-	FDCA
11.541	BB	4.30715	0.00000	0.00000	-	Furfural

Figure S4. 85: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (1 mmol), 100 °C, 60 min.



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Multiplier : 1.0000

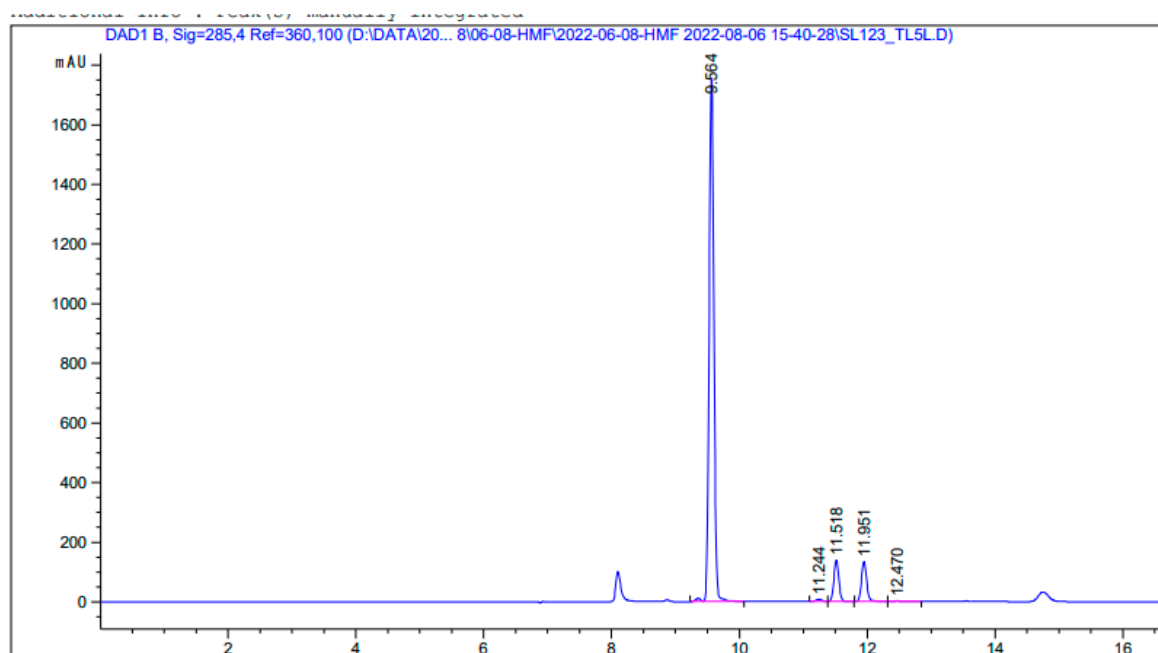
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Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.551	VV R	8978.54102	9.60502e-3	86.23908		HMF
10.201		-	-	-		DFF
11.097		-	-	-		FDCA
11.227	BV	45.71900	4.74997e-3	2.17164e-1		Furfural

Figure S4. 86: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (10 mmol), 100 °C, 5 min.



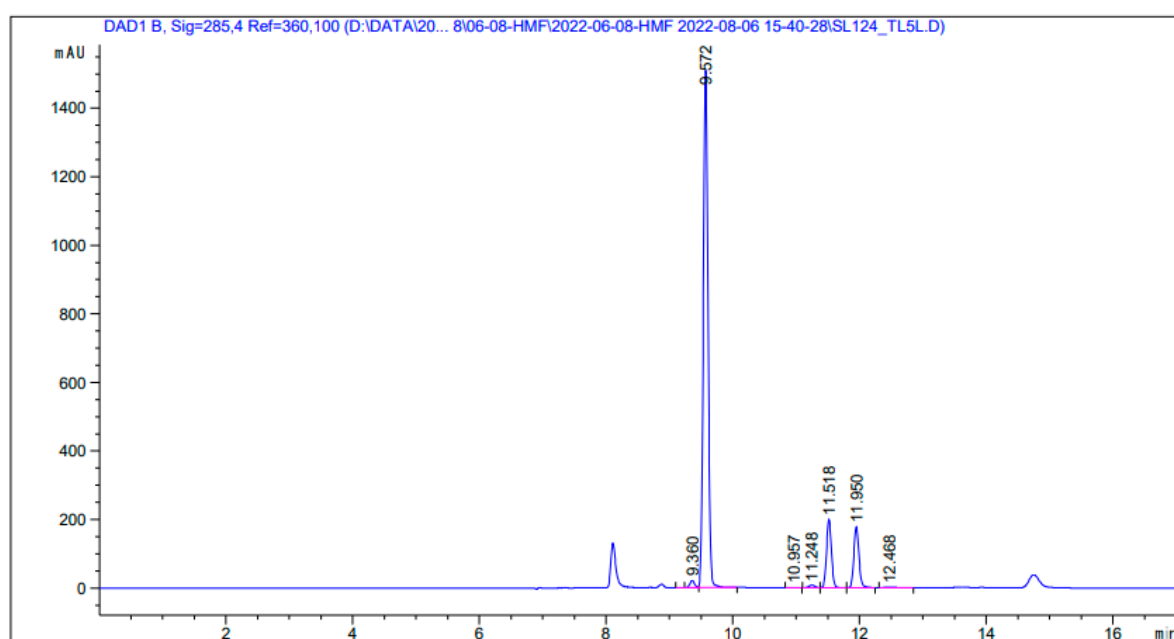
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.564	VB R	9100.50293	9.60562e-3	87.41594		HMF
10.201		-	-	-		DFF
11.097		-	-	-		FDCA
11.244	BV	48.74539	5.08930e-3	2.48080e-1		Furfural

Figure S4. 87: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (10 mmol), 100 °C, 10 min.



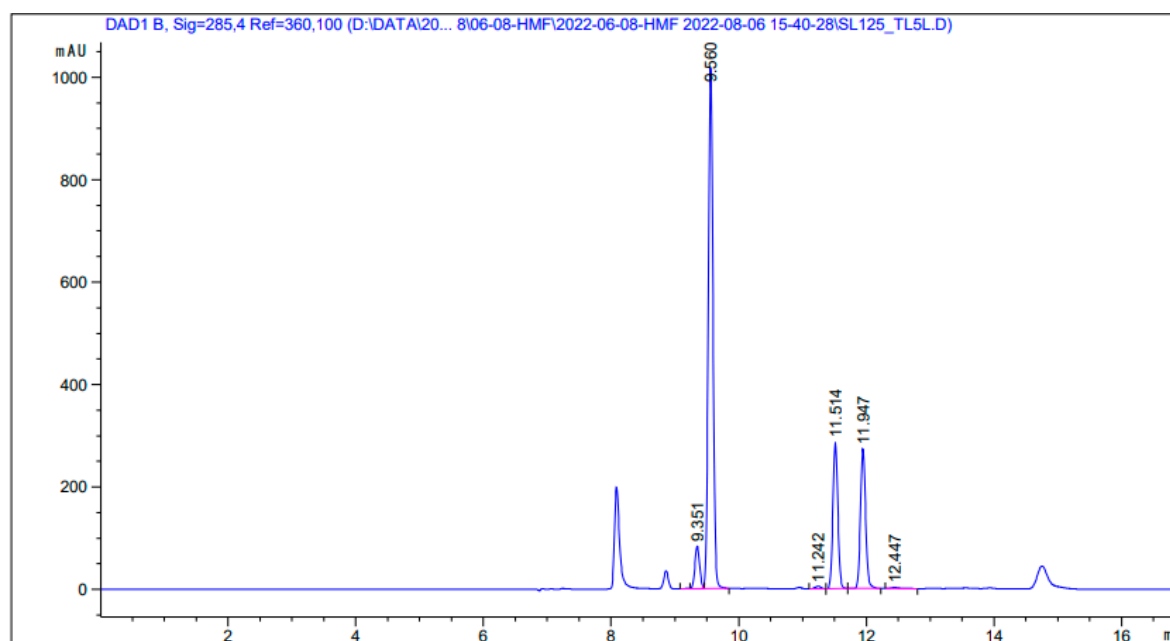
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Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.572	VB R	7739.05518	9.59791e-3	74.27877		HMF
10.201		-	-	-		DFF
10.957	BB	4.09889	0.00000	0.00000		FDCA
11.248	BV	46.98206	4.89691e-3	2.30067e-1		Furfural

Figure S4. 88: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (10 mmol), 100 °C, 20 min.



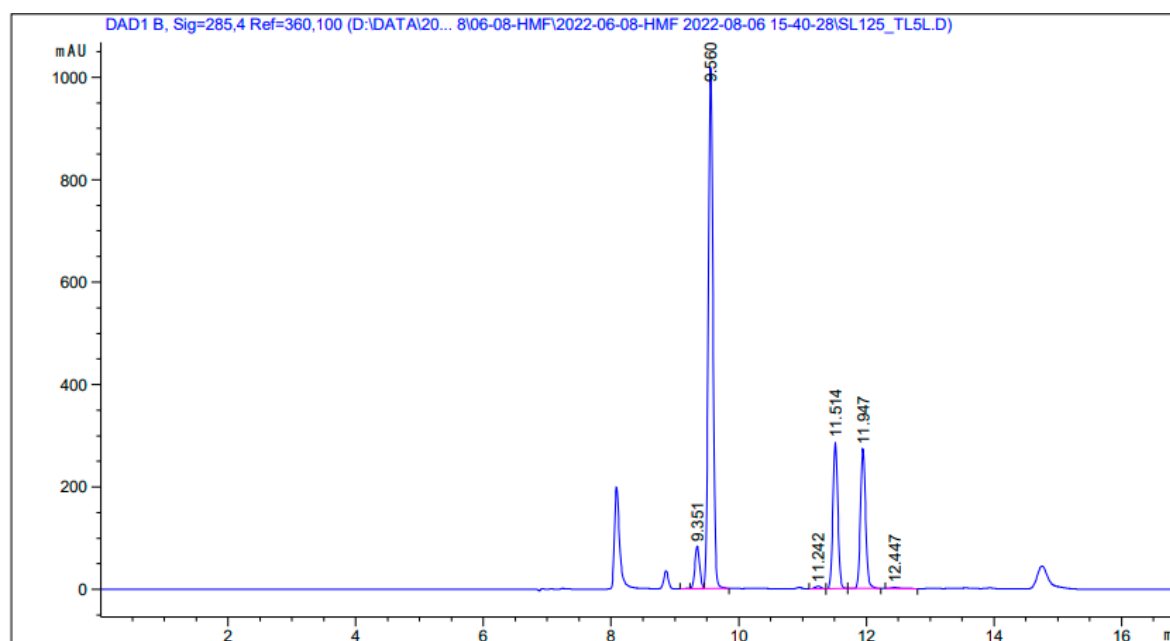
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 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.560	VB R	5204.16455	9.57283e-3	49.81857		HMF
10.201		-	-	-		DFF
11.097		-	-	-		FDCA
11.242	BB	30.24692	1.95422e-3	5.91090e-2		Furfural

Figure S4. 89: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (10 mmol), 100 °C, 30 min.



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 External Standard Report
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Sorted By : Signal
 Calib. Data Modified : 8/5/2022 1:49:08 AM
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 Dilution : 1.0000
 Do not use Multiplier & Dilution Factor with ISTDs

Signal 1: DAD1 B, Sig=285,4 Ref=360,100

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ppm]	Grp	Name
8.900		-	-	-		Levulinic acid
9.560	VB R	5204.16455	9.57283e-3	49.81857		HMF
10.201		-	-	-		DFF
11.097		-	-	-		FDCA
11.242	BB	30.24692	1.95422e-3	5.91090e-2		Furfural

Figure S4. 90: HPLC chromatography of HMF. Reaction condition: Fructose (1 mmol), DES 1 (10 mmol), 100 °C, 60 min.