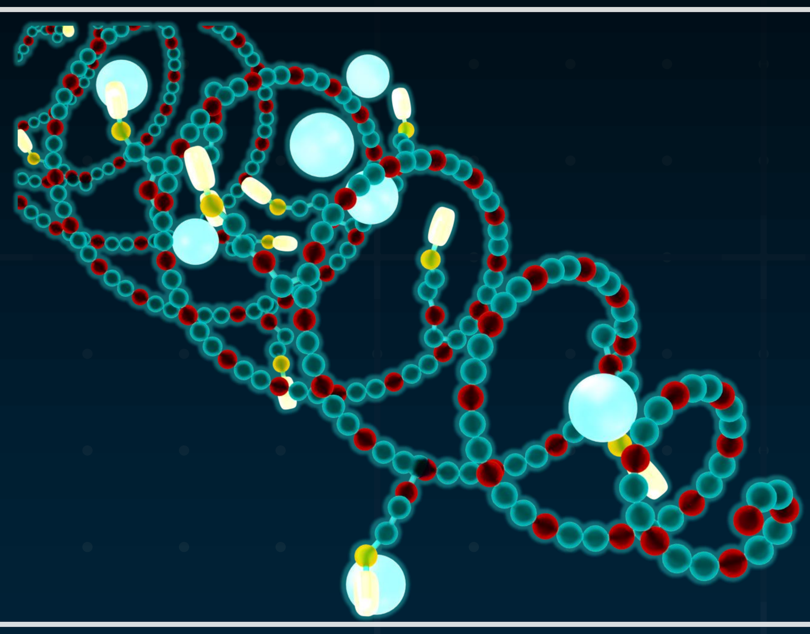
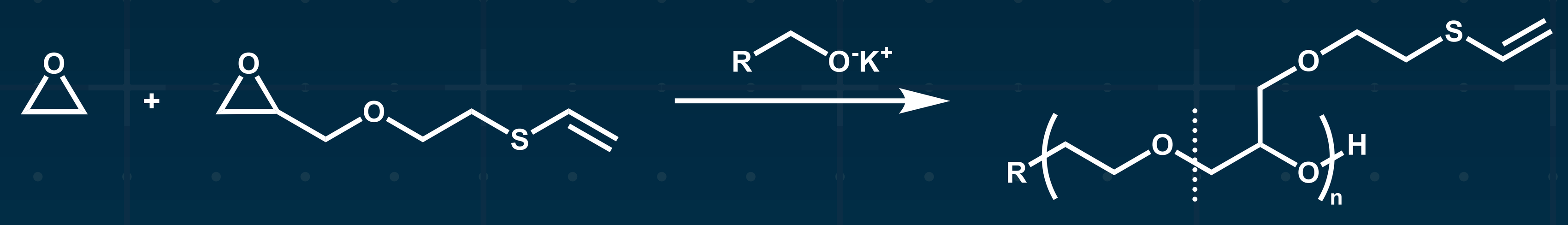
Solid State Single-Ion Conducting Polymer Electrolytes
Combining Polystyrene and sulfur-rich Polyethers

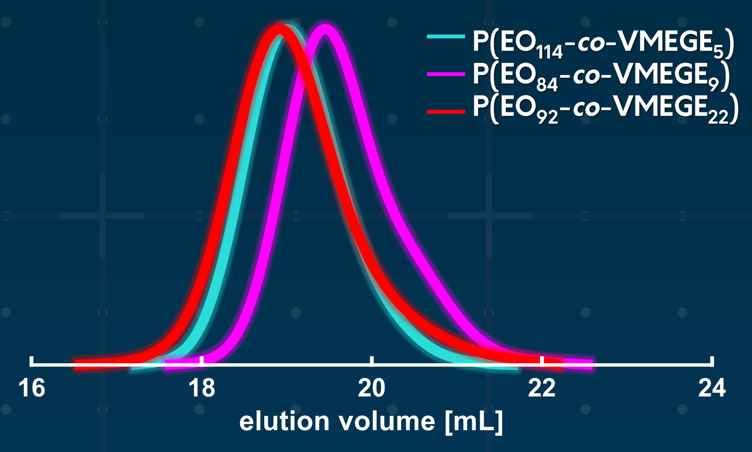
Tobias Gäb, Benny Mathes, Julius Sprengard and Holger Frey
Department of Chemistry, Johannes Gutenberg University, 55128 Mainz, Germany.
t.gaeb@uni-mainz.de, hfrey@uni-mainz.de

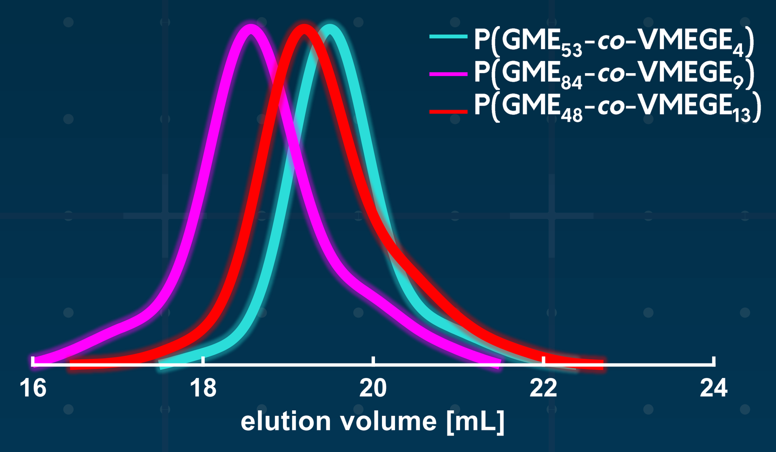
- Efficient energy storage systems are integral to the transition to renewables.
  - For E-mobility and mobile devices, high charging rates and energy densities are essential.
  - Current Li-Ion Batteries often suffer from dendrite formation and electrolyte decomposition, reducing their cycle life.
- Solid State Electrolytes open up the possibility of using Lithium metal as an anode instead of LFP/graphite, increasing energy density (170-370 mAh·g^{-1} to 3.860 mAh·g^{-1}).
  - Solid Polymer Electrolytes specifically suffer from low ionic conductivities and cross polarization, enabling dendrite formation.
  - Solutions to these two problems are amorphous conductive domains and anionic species tethered to the polymer backbone.

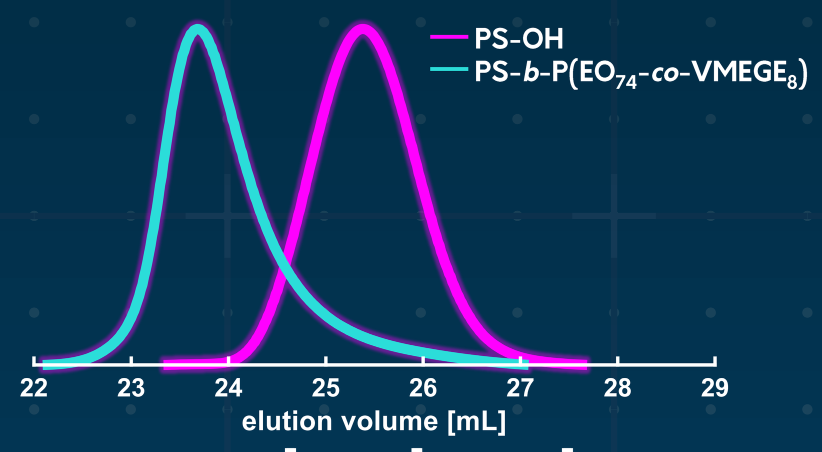


POLYMERIZATION

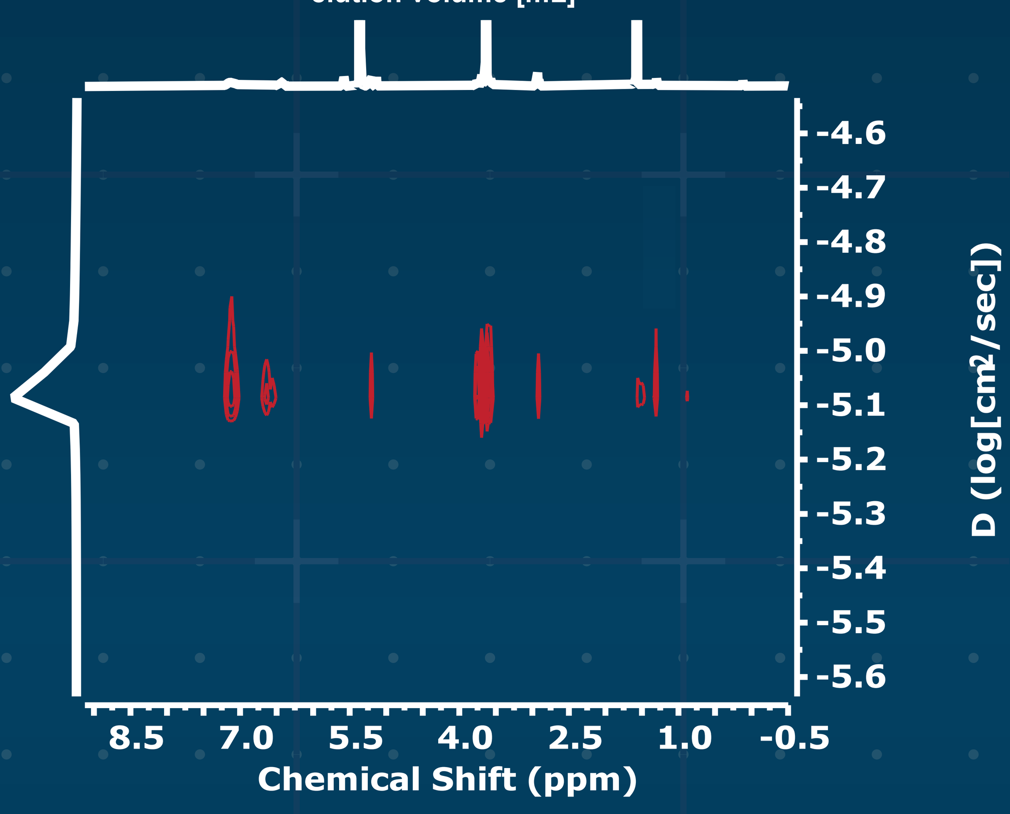




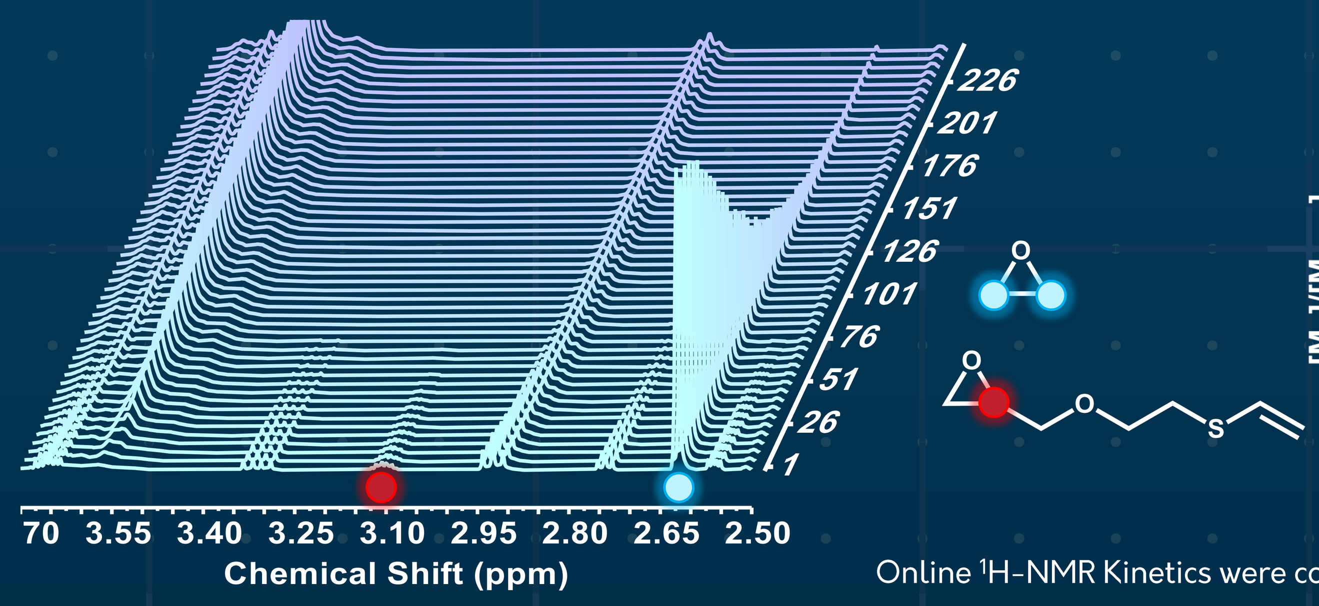


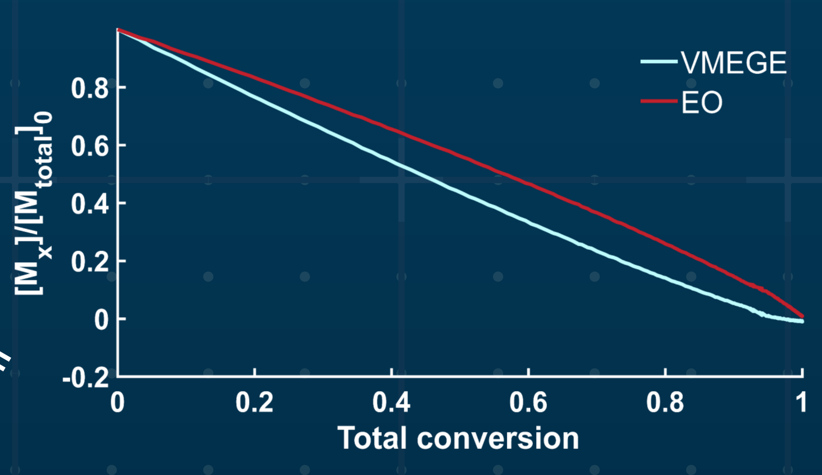


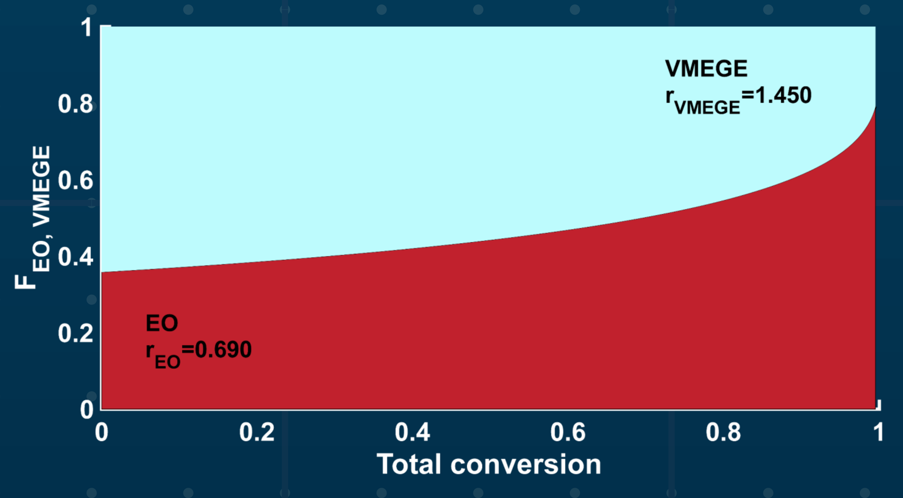
Sample	$M_{n,theo}$ [kg mol^{-1}]	$M_{n,SEC}$ [kg mol^{-1}]	$M_{n,MALDI}$ [kg mol^{-1}]	P_n [Polyether]	VMEGE [mol%]	Đ
P(EO$_{114}$-*co*-VMEGE$_5$)	5.1	4.8	6.0	119	5	1.07
P(EO$_{84}$-*co*-VMEGE$_9$)	5.6	3.8	5.2	93	9	1.08
P(EO$_{92}$-*co*-VMEGE$_{22}$)	6.8	4.9	7.6	113	19	1.10
P(GME$_{53}$-*co*-VMEGE$_4$)	9.3	4.0	5.5	58	7	1.10
P(GME$_{84}$-*co*-VMEGE$_9$)	9.6	5.6	9.0	94	10	1.07
P(GME$_{48}$-*co*-VMEGE$_{13}$)	10.4	4.2	6.5	62	22	1.14
PS-OH	6.0	5.6	5.9	-	-	1.05
PS-*b*-P(EO$_{74}$-*co*-VMEGE$_8$)	11.5	6.2	12.0	82	9	1.16



^{1}H-NMR KINETICS

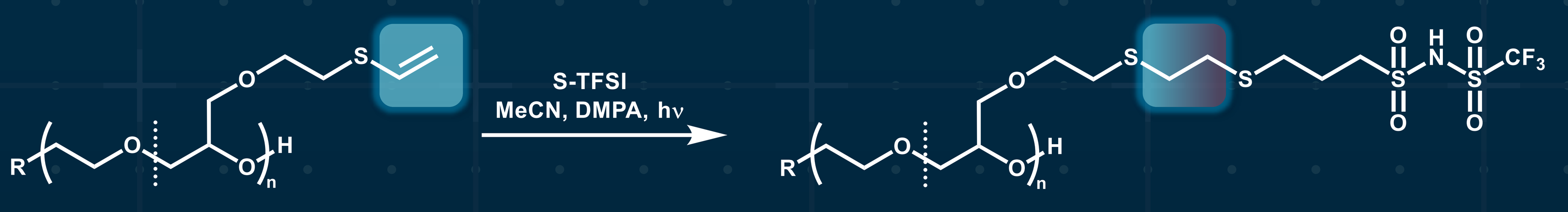


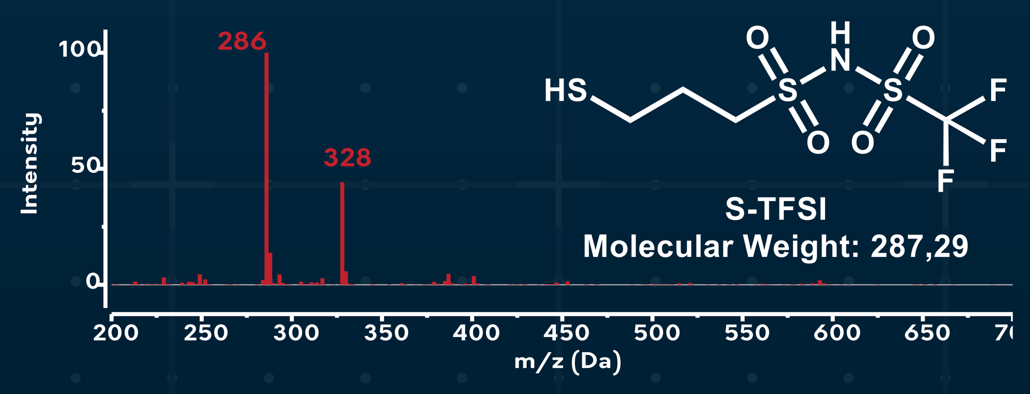


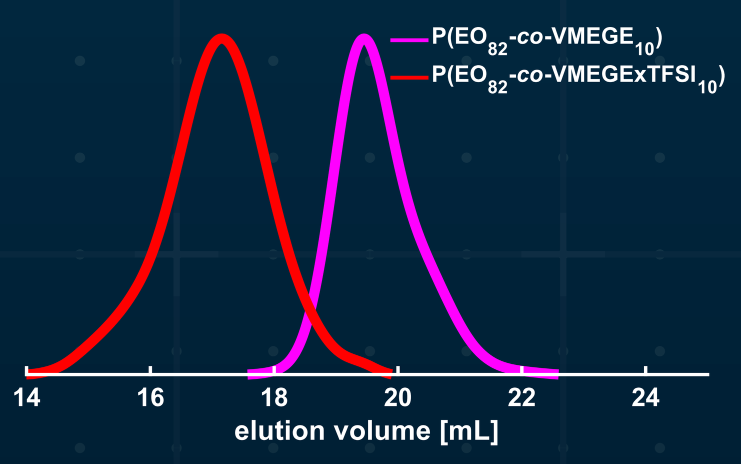


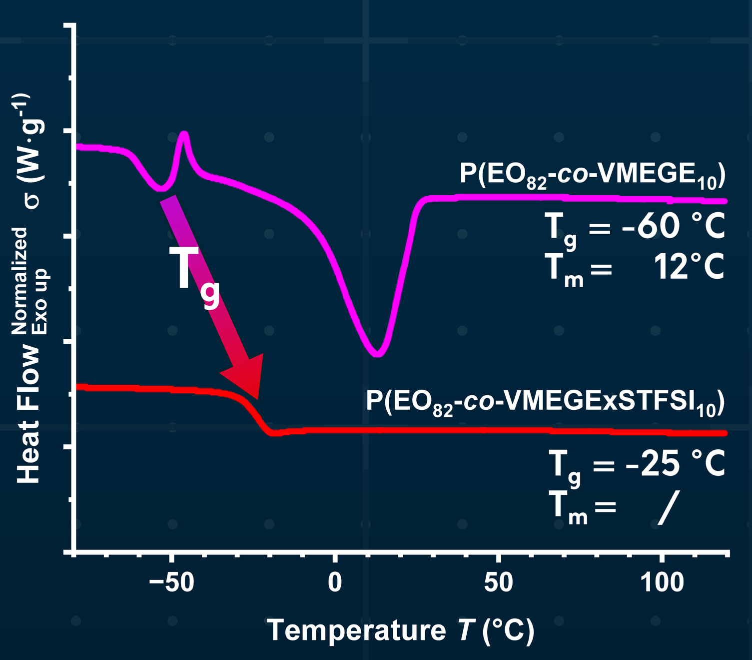
Online ^{1}H-NMR Kinetics were conducted on a 400 MHz device at 25 °C in d^6-DMSO.

POSTMODIFICATION









(Block) Copolymer Synthesis with bifunctional monomer

Online reaction kinetics of VMEGE/EO

Synthesis of TFSI-analogous Thiol

[1] B. Liu, J.-G. Zhang, W. Xu, Joule 2018, 2, 833.
[2] C. Julien, Lithium batteries: Science and technology, Springer international publishing 2016.
[3] J. B. Goodenough, Y. Kim, Chem. Mater. 2010, 22, 587.
[4] D. Karabelli, K. P. Birke, Applied Sciences 2021, 11, 7592.

epf GRONINGEN 2025

The Frey Group