Alternative sustainable binder and solvents for cathode application in LIB

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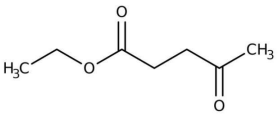
Challenge and Motivation

- NMP is quiet a problem of health and handling in the production process of cathode collector foils in lithium-ion batteries
- current studies* show an alternative solvent, Ɣ-valerolactone, for PVDF, but the mixing processing temperature is at 60°C
- with alternative binder like flexible epoxy binders which are soluble in Ɣ-valerolactone or ethyl 4-oxovalerate, the mixing process can be performed at ambient conditions
- the aim is to achieve a better handling and safe production with a better carbon footprint for lithium-ion batteries by using a biobased binder and biobased solvent systems with a view to consistent electrochemical performance of PVDF/NMP

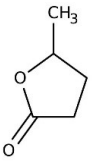
Alternative solvents



ethyl 4-oxovalerate

Boiling point: 203-205 °C

Flash point: 90-94 °C



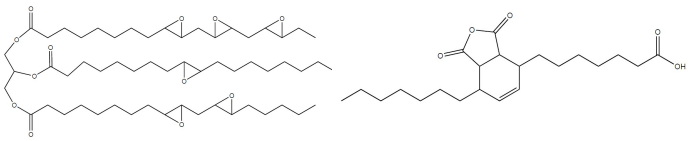
Ɣ-valerolactone

Boiling point: 205-206 °C

Flash point: 81 °C

Alternative flexible epoxy binders

- epoxy binders based on linseed oil (ELO) and curing agent are optimized by industry partner Hobum Oleochemicals GmbH
- increasing molecular weight by pre-polymerization of ELO, viscosity in the range of 4500 to 90000 mPa·s (ELO4500, ELO20000, ELO30000, ELO40000 and ELO90000)
- curing temperature at 140 °C – no question of pot life



epoxy binder: ELO before pre-polymerization

curing agent: 8-(7-hexyl-1,3-dioxo-3a,4,7,7a-tetrahydro-2-benzofuran-4-yl)octanoic acid

Slurry preparation and application

- slurry preperation by dissolver mixing under ambient conditions
- binder (4 w.-%), NMC622 (94 w.-%), carbon black (2 w.-%)
- biobased solvent content smaler then 25 w.-%
- rheological study right after preparation
- curing at 140 °C for 2 h and subsequently drying at 80 °C for 24 h
- characterization by LSM, adhesion by means of tape film and wrapping tests

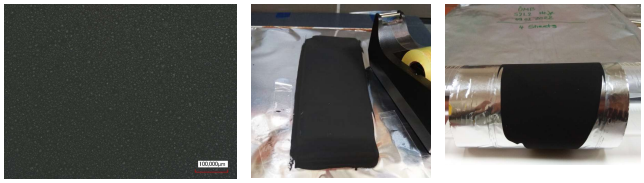


Fig. 1-3: Surface characterization by LSM, tape adhesion and wrapping tests

Results and Outlook

	Slurry 1 ELO	Slurry 2 ELO4500	Slurry 3 ELO20000	Slurry 4 ELO30000
ethyl 4-oxovalerate	adhesion - cracks	adhesion - cracks	adhesion - cracks	adhesion - cracks
Ɣ-valerolactone	adhesion - cracks	**adhesion +++** **no cracks**	adhesion +++ cracks	adhesion +++ cracks
Observation	strong sedimentation inhomogenious films			

Tab.1: Influence of ELO pre-polymerization to slurry preparation, surface, adhesive and wrapping tests

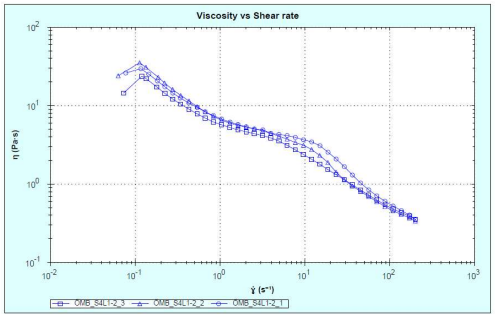


Fig. 4: Shear viscosity behavior as a function of shear rate of Slurry 4 with 18 w.-% solvent content

- rheological studies show a shear-thickening behavior at a shear rate of 10 s^{-1} and sedimentation stability at 18 w.-% solvent content
- optimazation in slurry formulation by reducing the binder solvent content and adjusting the stoichiometry of epoxy binders and curing agent for more flexibility because slurries with ELO20000 and ELO30000 show cracks at wrapping tests
- LSM surface tests are satisfied hereby smallest cracks can be seen sporadically
- electrochemical performance tests for optimized formulations are planed. Two references, PVDF/NMP and PVDF/GVL, serve for comparison

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* Schmitt-Hansberg et al., ACS Appl. Energy Mater. 2021, 4, 696-703