

Characterization of three-component blend poly(lactide)-poly(ethylene oxide)-lithium salt dedicated for use in lithium-ion battery as solid polymer electrolyte

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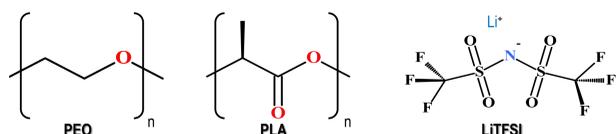
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In the field of large batteries designed for use in electric or hybrid vehicles as well as for load-leveling, there is an urge for safer, thermally and electrochemically stable electrolytes with high ionic conductivity and excellent ion transport properties. Lithium cells are the most common sources of electricity that are used to power mobile devices. The choice of the right electrolyte has a significant impact on the properties and parameters of the battery. Currently, one of the most applicable solution designed for constructing lithium cells are solid polymer electrolytes, which are composed of a polymer matrix containing a lithium salt. They have the advantage over the liquid electrolytes since they give the possibility of forming thin films and also act like a separator.

AIM & MATERIALS

In presented work the main aim was to propose a preparation method for obtaining a three-component blend poly(lactide)-poly(ethylene oxide)-lithium salt (LiTFSI) mixture and then its characterization in term of use in lithium cells as solid polymer electrolyte.



PREPARATION & ANALYSIS

1st Stage

- preparation of the polymer matrix consisted of PEO and PLA in various weight ratios by using the "film casting" method
- use of the two different drying techniques, either rapid evaporation of the solvent or using the molecular sieves

In this part the **DSC**, **SEM** and **Raman spectroscopy** were used to verify the homogeneity of the sample.

2nd Stage

- preparation of the three-component blend - PEO-PLA-LiTFSI (membrane was prepared with the LiTFSI salt in different weight ratios of oxygen from polymers to lithium).
- Obtained samples were examined by **DSC** and the **Raman spectroscopy**. Also **electrochemical tests** were performed.

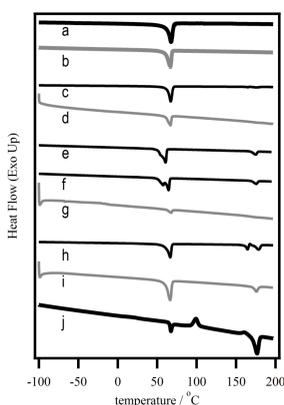


SAMPLES WITHOUT SALT

Dried by using the molecular sieves

PEO:PLA	PLA [g]	PEO [g]
5:1	0,08	0,36
2:1	0,15	0,29
1:1	0,22	0,22
	0	0,44

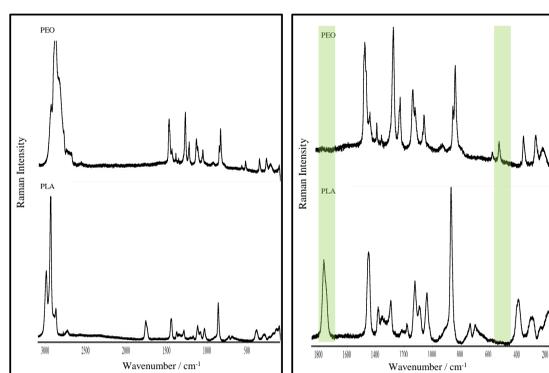
DSC



Sample	T _g /°C	PEO	PLA
PEO (1)	-58,25	67,64	-
PEO (2)	-54,54	66,00	-
5:1 (1)	-55,89	67,13	175,99
5:1 (2)	-55,60	66,92	176,61
2:1 (1)	-52,71	(55,06); 64,49	175,65
2:1 (1')	-52,63	64,40	175,65
2:1 (2)	-51,20	67,74	175,79
1:1 (1)	-55,81	66,52	178,61
1:1 (2)	-53,63	66,51	175,94
PLA	-	-	176,58

DSC data of membranes obtained by the rapid evaporation of the solvent – **black** or by storage over molecular sieves – **gray**, in which **PEO to PLA ratio** is equal to: 5:1 (c, d); 2:1 (e, f, g); 1:1 (h, i); and for pure PEO (a, b) and PLA (j).

RAMAN SPECTROSCOPY



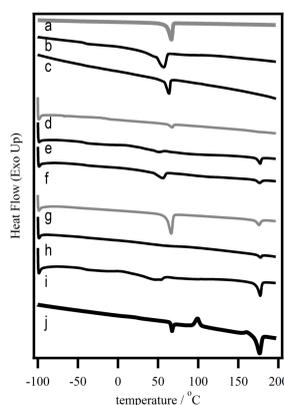
Sample	Area at 530 cm ⁻¹ (A)	Area at 1760 cm ⁻¹ (B)	B:A ratio
5:1 (1, up)	5176	11453	2,2
5:1 (1, down)	1865	4792	2,6
5:1 (1', up)	5528	8485	1,5
5:1 (1', down)	2500	3970	1,6
5:1 (2)	16250	14744	0,9
2:1 (1)	3954	9049	2,3
2:1 (1')	5171	9773	1,9
2:1 (2)	16000	42221	2,6
1:1 (1)	1581	11101	7,0
1:1 (2)	616	3526	5,7

Raman spectra obtained for PEO and PLA membranes in the 100-3100 cm⁻¹ (right) and 100-1800 cm⁻¹ spectral range (left).

SAMPLES WITH LiTFSI

PEO:PLA	PLA [g]	PEO [g]	Li:O	LiTFSI [g]
-	-	0,44	1,20	0,1435
-	-	0,44	1,30	0,0957
1:1	0,22	0,22	1,20	0,1063
1:1	0,22	0,22	1,30	0,1590
2:1	0,15	0,29	1,20	0,1545
2:1	0,15	0,29	1,30	0,1030

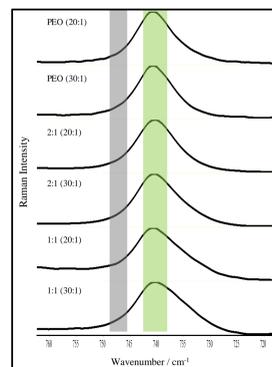
DSC



Sample	T _g /°C	PEO	PLA
PEO	-54,54	66,00	-
PEO (20:1)	-41,19	63,00	-
PEO (30:1)	-43,34	63,80	-
2:1	-51,20	67,74	175,79
2:1 (20:1)	-42,46	50,64	177,50
2:1 (30:1)	-39,87	56,06	176,77
1:1	-53,63	66,51	175,94
1:1 (20:1)	-39,94	55,42	177,78
1:1 (30:1)	-44,73	46,62	177,47
PLA	-	-	176,58

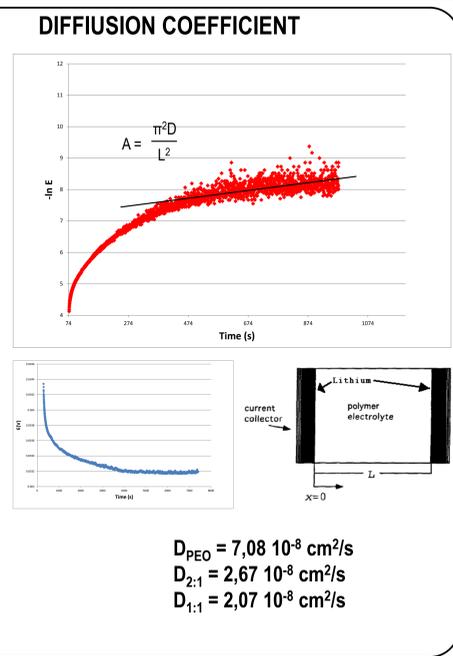
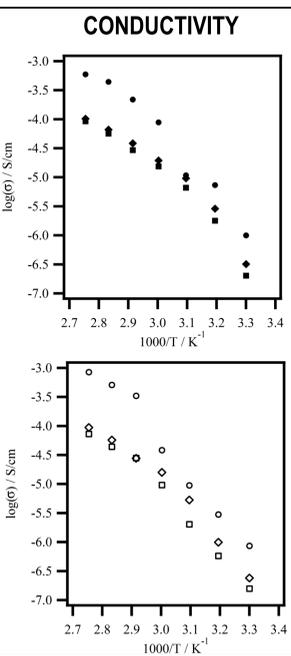
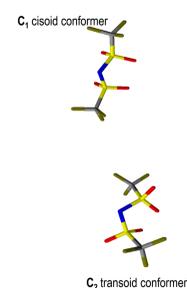
DSC data of membranes containing LiTFSI salt – **black** or without salt – **gray**, in which **PEO to PLA ratio** is equal to: 2:1 (d, e, f); 1:1 (g, h, i); 1:1 (h, i); and for PEO (a, b, c) and PLA (j).

RAMAN SPECTROSCOPY



Higher agglomerates	Li(C ₂) ₂	Li(C ₁) ₂	"Free" C ₁	"Free" C ₂
749-757cm ⁻¹	749,5cm ⁻¹	747,5cm ⁻¹	744-741cm ⁻¹	741-738cm ⁻¹
				Li(C ₁ C ₂) 748cm ⁻¹

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CONCLUSIONS

- use of the molecular sieves during the drying process provide to higher homogeneity of the samples
- addition of LiTFSI salt causes increase of glass transition temperature and lowers melting temperature of PEO, it serves as a plasticizer for the system
- in recieved membranes there are only free ions originated from lithium salt and no signs of higher conglomerates
- addition of PLA to PEO matrix lowers the diffusion coefficient of lithium cation in recieved membranes

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