

ELECTROCHEMICAL PROPERTIES OF GEL POLYMER ELECTROLYTES MODIFIED FLAME RETARDANTS

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Abstract: This paper deals with preparation of gel polymer electrolytes modified by flame retardants based on methyl methacrylate. The aim of this work was to investigate the effect of thermal polymerization method on electrochemical properties such as ionic conductivity and potential window of gel polymer electrolytes. For measuring electrochemical properties, impedance spectroscopic techniques and linear voltammetry were used. Results indicate the dependence of ionic conductivity on the amount of flame retardant.

Keywords: flame retardant, polymer, gel polymer electrolyte, methyl methacrylate, ionic conductivity

1 INTRODUCTION

Rechargeable lithium ion batteries, which are one of the most important technologies for energy storage, play a vital role in the modern world and have become an integral part of our everyday life. They are now used in many portable devices such as mobile phones, laptops, digital cameras and more. Li batteries have a long life cycle, but many aspects like improvement in safety, energy density, cost reduction, flammability and other are required [3,4].

Gel polymer electrolytes attract the attention of many researchers worldwide for their application in different electrochemical devices. The use of polymeric electrolytes is widely regarded as a promising approach for lithium ion batteries due to their high ionic conductivity at ambient temperature and a reduction in the risk of leakage of the electrolyte solution. Research focuses on the development of new gel polymer electrolytes with high ionic conductivity, good mechanical properties and thermal stability [2,6,7,8].

Polymer methacrylate based systems have the advantage of wide availability, low toxicity and good electrochemical stability. These polymer gels, which are based on conductive salt, have a number of advantages over the previous liquid electrolytes. The most important advantages are elimination of the risk of electrolyte spillage, high safety, high shape flexibility, low reactivity due to solid component of gel, low density, resistance to mechanical stress, high temperatures, pressures, and vibrations [2,7].

Flame retardants are chemical compounds that are added to materials or otherwise incorporated to plastic compounds to provide varying degrees of flammability protection. These chemicals increase fire resistance, especially by reducing the ease with which a polymer burns [1].

There are many different types of flame retardants with distinct properties. For the preparation of gel electrolytes based on MMA, different phosphorous-based flame retardants were chosen. This type of flame retardants shows to some extent a high flame retardancy. They facilitate the formation of a carbonized layer by burning, and this charred layer blocks oxygen and radiation heat, whereby it is considered that burning is suppressed [1].

3 RESULTS AND DISCUSSION

During this work, three series of gel polymer electrolytes with selected flame retardants were prepared. Every series consists of five samples which differ from each other by concentration of selected flame retardant. The concentrations of 10%, 15%, 25%, 50% and 75% were chosen for modifier. Gel samples were prepared in glove box with argon atmosphere JACOMEX. Sample resp. gel polymer electrolyte is circular gel with a diameter 16 mm and defined thickness 0,9 mm, which is cut out from the total area of formed polymerized gel. The electrochemical properties of gel samples (ionic conductivity, potential window) were measured with electrochemical test cell EL-CELL using potentiostat Eco AutoLab.

In Figure 3, gel electrolytes with TEP after gelling are shown. In Figure 4, samples with TBP after gelling are shown. All gel samples were elastic, flexible, clear, non-adhesive and have a good manipulation.

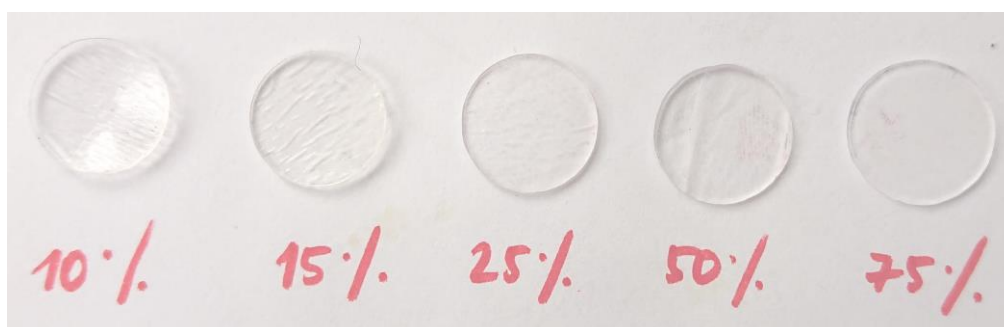


Figure 3: Photographs of the gel polymer electrolytes with different concentration of TEP after gelling

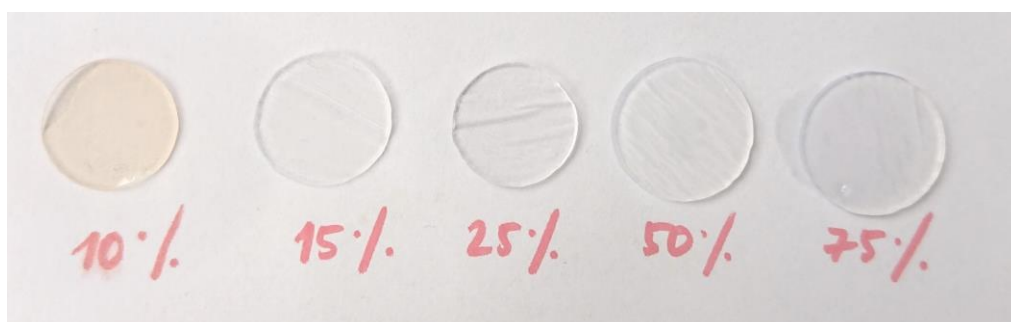


Figure 4: Photographs of the gel polymer electrolytes with different concentration of TBP after gelling

The measured results of gel polymer electrolytes are shown in Table 1 and Table 2. The comparison of ionic conductivity with TEP and TBP is shown in Figure 5. In Figure 6, graphs of potential windows for gel samples with TEP and TBP are shown.

TEP					
V_{FR} [%]	10	15	25	50	75
γ [mS/cm]	2,88	1,99	3,27	3,23	4,87
TBP					
V_{FR} [%]	10	15	25	50	75
γ [mS/cm]	3,54	3,54	3,06	5,15	3,97

Table 1: Ionic conductivity of gel polymer electrolytes with flame retardants

TEP					
V_{FR} [%]	10	15	25	50	75
5 μ A [V]	-	2,75	-	3,29	3,34
10 μ A [V]	-	4,53	-	3,73	3,82
TBP					
V_{FR} [%]	10	15	25	50	75
5 μ A [V]		4,49	2,12	4,35	3,42
10 μ A [V]		4,99	3,75	4,92	4,20

Table 2: Potential window of gel polymer electrolytes with flame retardants

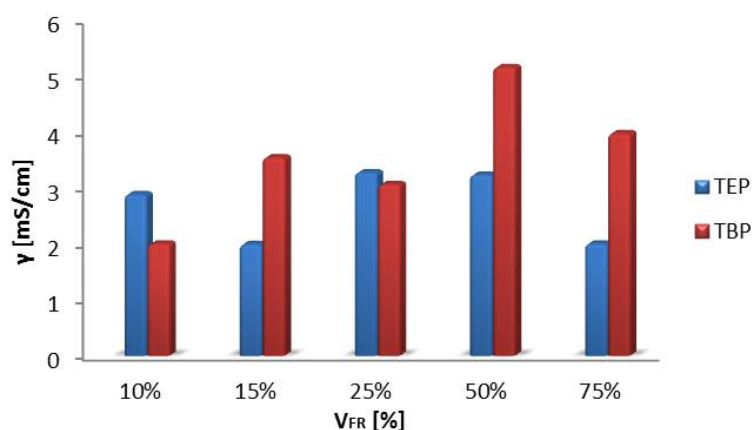


Figure 5: Comparison of ionic conductivity with selected flame retardants

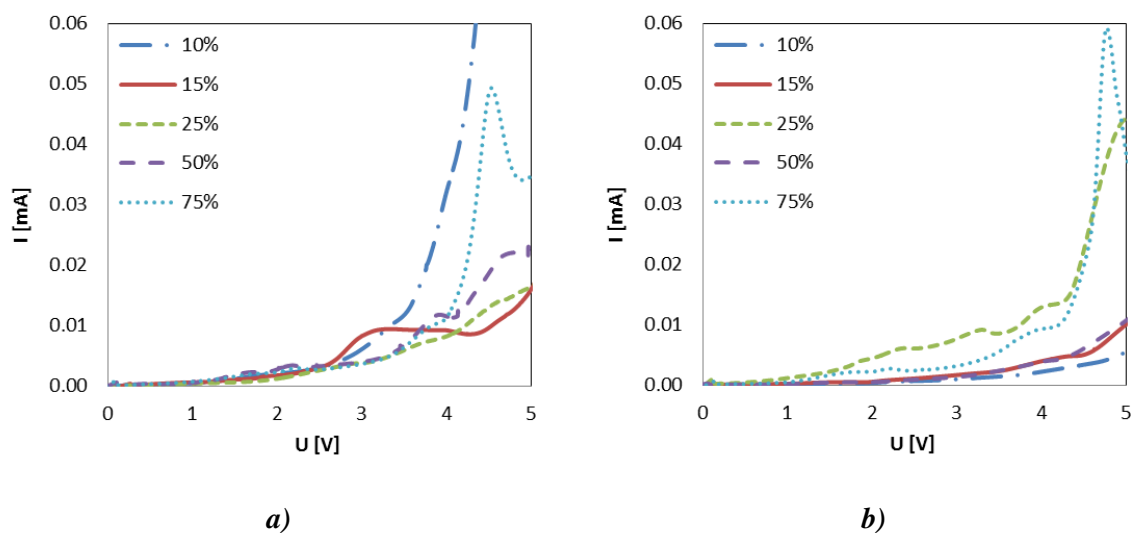


Figure 6: Potential windows of gel polymer electrolytes with selected retardands: **a)** TEP; **b)** TBP

4 CONCLUSION

Experimental measurements in this work served as the initial studies on the gel polymer electrolytes with flame retardants. The paper has shown that different concentration of flame retardant in chemical composition of gel polymer electrolyte has a considerable influence on electrochemical

and mechanical properties. The best electrochemical and mechanical properties have gel electrolytes with flame retardant TBP, the value of ionic conductivity of these samples were more than 3 mS/cm. The highest ionic conductivity was 5,15 mS/cm (gel polymer electrolyte with 50% TBP). The potential window of this sample was high. Further research will be focused on thermal properties and use of Li-ion cells.

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