# A New Room-Temperature Molten Salt Electrolyte

**Title and Subtitle**

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**Abstract**

The evaluation of room-temperature molten salt systems as suitable electrolytes for battery applications is a subject of ongoing research in our laboratory. Several room-temperature molten salt systems have been reported (1-4). One of particular interest to us has been the 1-methyl-3-ethylimidazolium chloride (MEIC)/AlCl3 system (3).
A New Room-Temperature Molten Salt Electrolyte

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The evaluation of room-temperature molten salt systems as suitable electrolytes for battery applications is a subject of ongoing research in our laboratory. Several room-temperature molten salt systems have been reported (1-4). One of particular interest to us has been the 1-methyl-3-ethylimidazolium chloride (MEIC)/AlCl₃ system (3). These melts are described in terms of their apparent mole fraction, \( N \), of AlCl₃. Melts with \( N < 0.5 \) are basic due to the presence of the Cl⁻ anion, and melts with \( N > 0.5 \) are acidic due to the presence of the AlCl₄⁻ anion. In basic melts, the anodic ethoxymethyl group in the melt is the oxidation of chloride ions and the cathodic limit the reduction of the organic cation resulting in an electrochemical window of approximately 3V (5).

The tetraalkylammonium chloride salt chosen was dimethylethanolhexymethyl ammonium chloride (N₂₁₁₀₂Cl). The tetraalkylammonium chloride is described by a numerical designation in which the ones and twos refer to the number of carbon atoms in the alkyl side chains attached to the central nitrogen atom. When an oxygen atom is encountered in the side chain, an “O” is added to the number and the numbers on either side denote the carbon atoms adjacent to the oxygen (as in the “102” designation for the ethoxymethyl group in N₂₁₁₀₂Cl).

Experimental

The N₂₁₁₀₂Cl is prepared by dropwise addition of dimethylethanol to chloromethylethyl ether at 25°C with diethyl ether as the solvent. The reaction is run for 4h. The solvent is removed by cannula and the product dried under vacuum. The yield is 90% with no further purification needed. The addition of AlCl₃ to N₂₁₁₀₂Cl causes an exothermic reaction to occur, similar to the MEIC/AlCl₃ molten salt system. The heat generated in the mixing process can lead to decomposition of the melt; therefore, to prepare a melt, the aluminum chloride was added slowly to the N₂₁₁₀₂Cl. Melts in which the apparent mole fraction, \( N \), of AlCl₃ was ~0.5 decomposed, giving off ethyl chloride. Ethyl chloride was identified by sampling the headspace above the melt with a gas-tight syringe followed by analysis by gas chromatography-mass spectrometry (GC/MS). Therefore, only melts with an apparent mole fraction AlCl₃ of less than 0.5 were studied. The GC/MS analysis was carried out on a Hewlett Packard (Palo Alto, California) 5985.
melt systems. Fig. 1, shows a wider electrochemical window by 0.7V for the N₂11 10²Cl/AlCl₃ system than for the MEIC/AlCl₃ system due to the lower reduction potential for N₂11 10²⁺ cation.

The reduction waves at -2.2 and -1.8V were not explored further. Based on our experiences with other room temperature molten salt systems, these waves are most likely due to organic impurities encountered in the synthesis and traces of water from the acetonitrile used to recrystallize the organic salt. The ²⁷Al nuclear magnetic resonance images for several compositions of the melt show the predominant Al species to be AlCl₄⁻. This is also similar to the MEIC/AlCl₃ system. The inability to plate aluminum from basic melts of either system is probably due to the stability of the AlCl₄⁻ anion. The specific conductance of the new melt system was also studied. Compared with melts of similar compositions of the MEIC/AlCl₃ system (7), the new melt systems’ specific conductance is lower by a factor of four. Like the MEIC/AlCl₃ system, the specific conductance of N₂11 10²Cl/AlCl₃ melts increases upon the addition of benzene.

Conclusion

The new room-temperature molten salt system described has a wider electrochemical window and lower specific conductance than the MEIC/AlCl₃ system. The presence of the AlCl₄⁻ anion is common to basic compositions of the two melt systems, as is the electrochemical behavior of certain metals and metal halides. No further work is planned on this system.

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REFERENCES