



Electrochemical Behavior of Tin and Bismuth in Dynamic Windows

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Abstract

This presentation covers the findings of the complex interactions of aqueous ionic compounds for use in reversible metal electrodeposition dynamic windows. We maximized the amount of light that could be blocked in the window but also the reversibility of the process. We developed two systems based on the metal that was plated onto the working electrode, these two systems are the tin and bismuth systems. We found that hydrochloric acid was best for what we needed, a little lithium chloride greatly improved both systems but too much harmed them. Finally, the bismuth system was greatly improved with the addition of iron, but iron hurt the tin system.

Introduction

The relationships in electrolytes found in this research will help future studies on dynamic windows by supplying a more comprehensive understanding of the interactions at work in these two electrolytes.

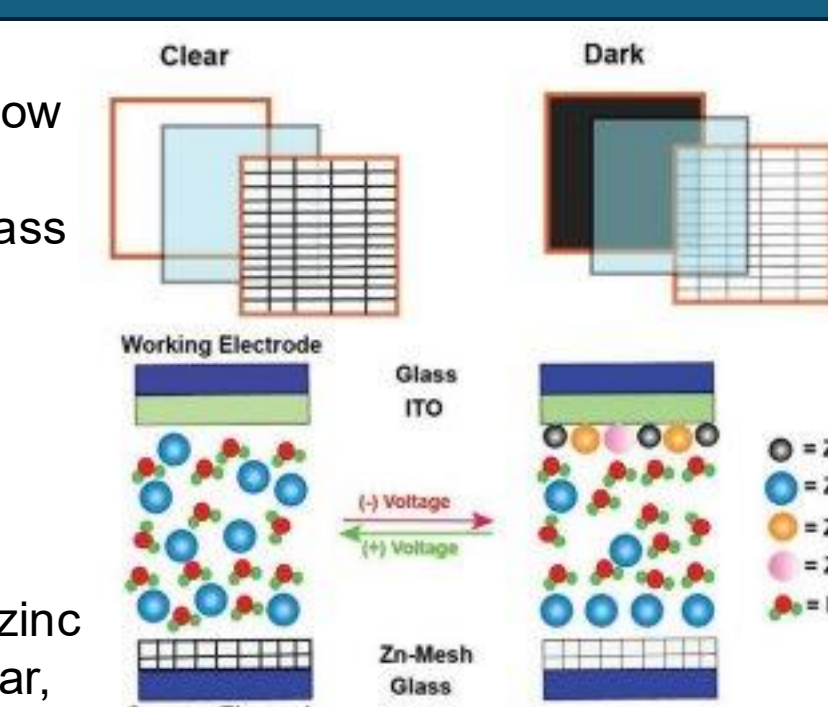
The electrolytes were evaluated on how much light was blocked and the reversibility of the system back to clear on FTO.

What is a Dynamic window

A dynamic window is a type of window that electrically controls its transparency. The two main types are Electrochromic which uses a solid material and Electrodeposition which uses an electrolyte.

we use the Electrodeposition method as it has faster switching times and can reach lower transparency. These windows reduce power consumption required by climate and lighting systems

Schematic of dynamic window for reversible Zn electrodeposition on ITO/glass WE and Zn mesh CE.



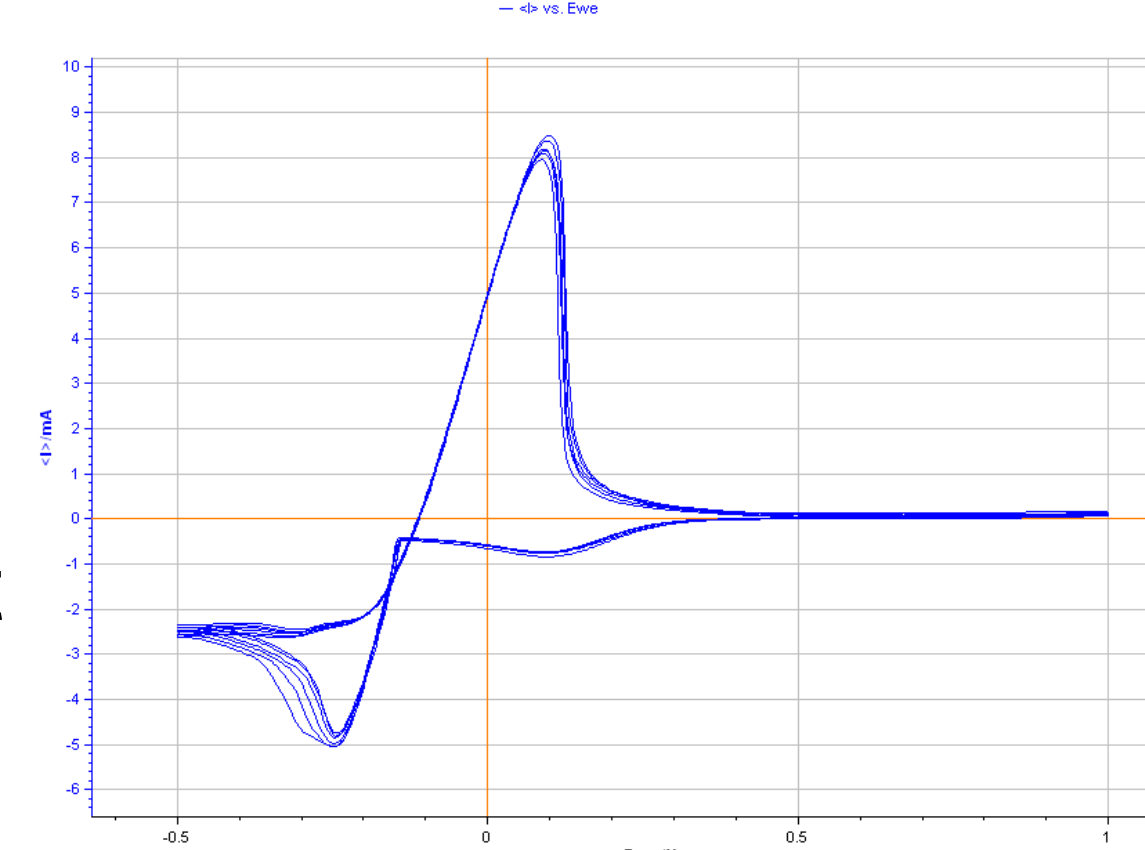
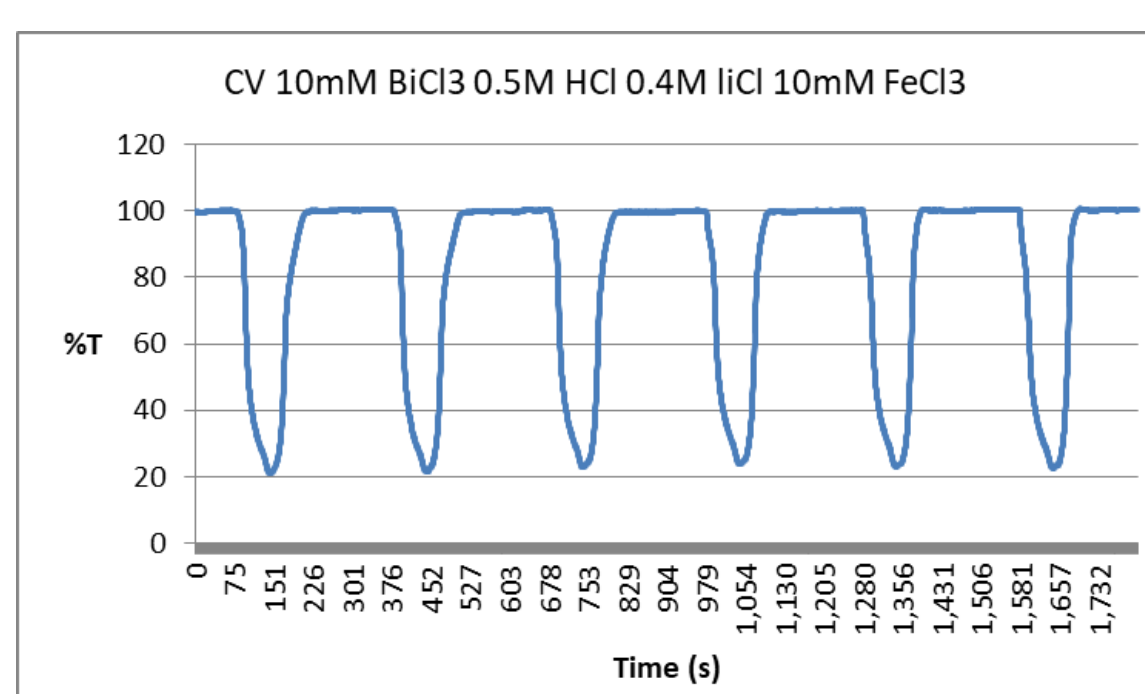
A 25 cm² test window using a zinc solution and ITO glass in it clear, transition, and dark phases.



Bismuth Electrolyte

The Bismuth electrolyte system was the first one we investigated. This system uses Bismuth (III) chloride as its main active compound. Where the bismuth ions in solution get reduced to metal on the glass part of the window.

Bismuth chloride both forms hydroxides and has a solid compound when not enough chloride ions are present in the solution making hydrochloric acid preferable to reduce the amount lithium chloride required to get a fully clear solution.

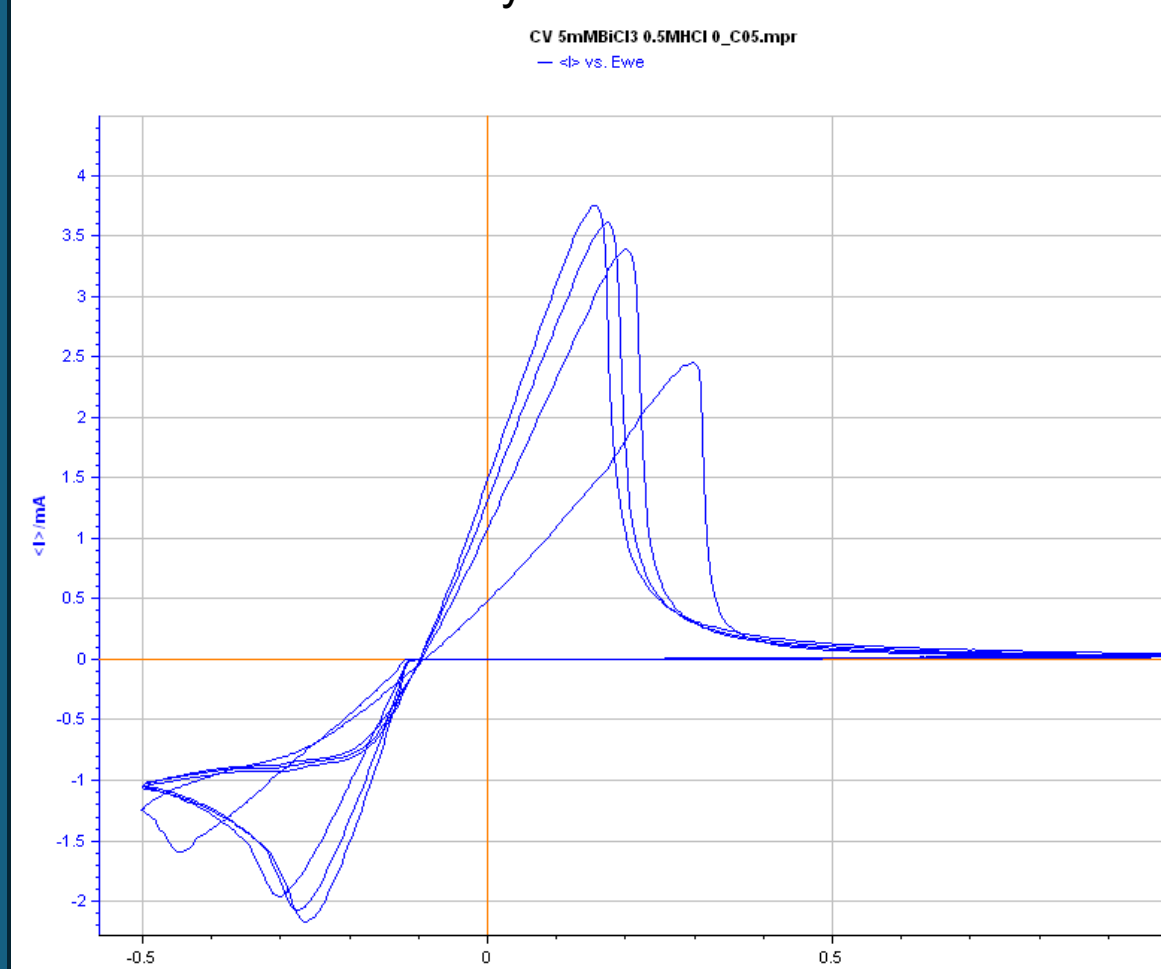


Lithium chloride while helpful in the proper amounts it can reduce plating ability and reversibility if overused. Iron (III) chloride is also required in the bismuth system in very small amounts as it drastically increases both palatability and reversibility which can cause instabilities if amounts are overly increased.

Hydrochloric Acid

Hydrochloric acid has two main benefits. The first is that electrolytes using this acid have showed a small increase in reversibility. The second is that for the bismuth system much less lithium chloride was necessary as the acid increased chloride ion concentration as well. The one drawback is the reduced stability of the system.

CV of a 5mMBiCl3 0.5MHCl 0.33MLiCl system.



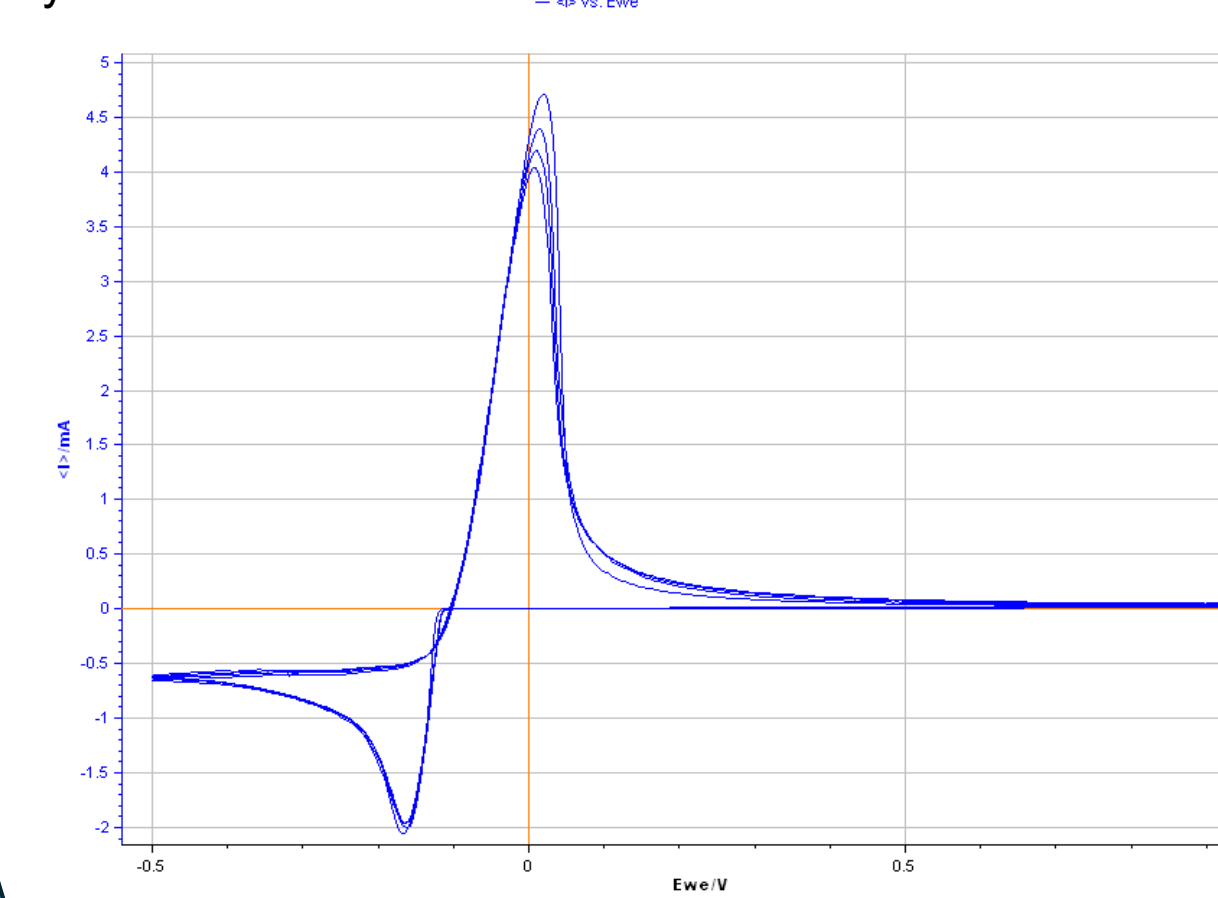
Di Water

We used DI water as a control when we tested the other acids to see if an acidic solution was needed at all. It was shown that an acidic solution is required as in pH neutral or basic solutions insoluble hydroxides form immediately resulting in a cloudy solution. This drastically reduced the initial transparency of the window rendering it unusable in a window.

Sulfuric Acid

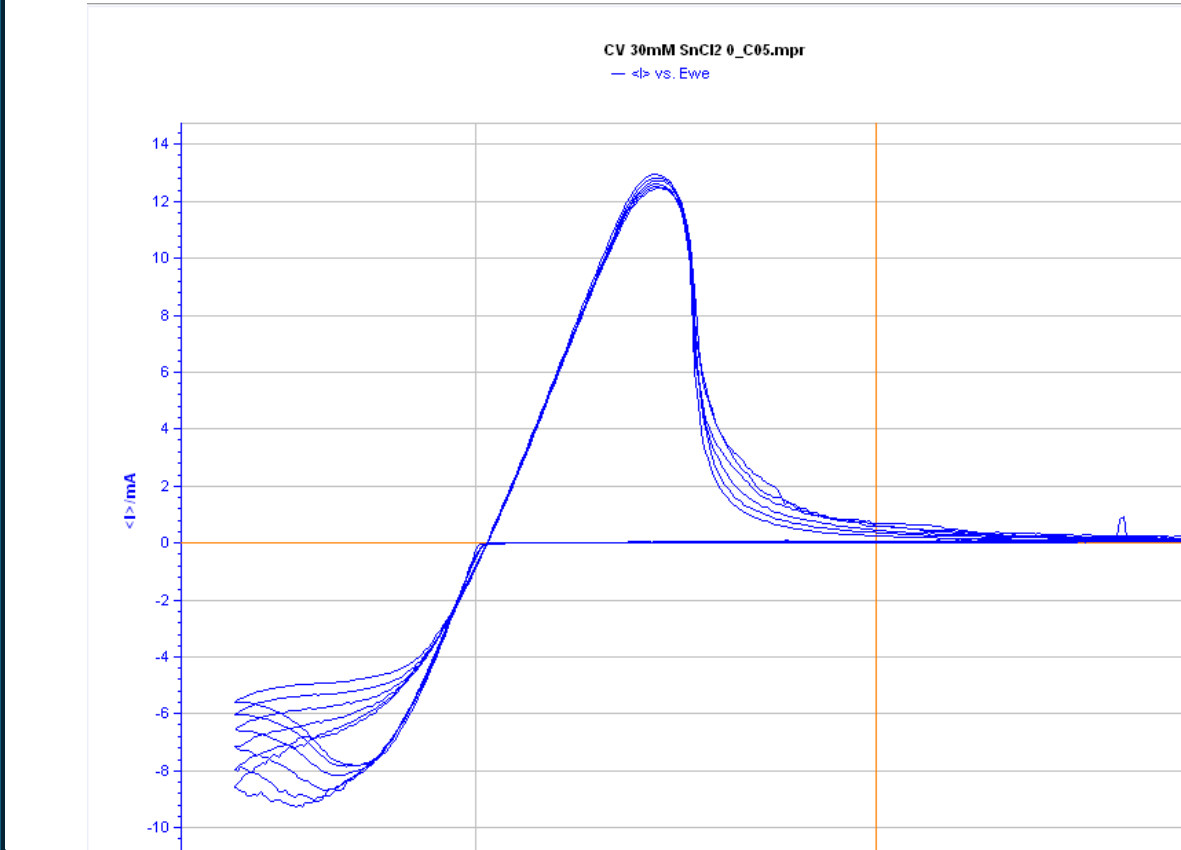
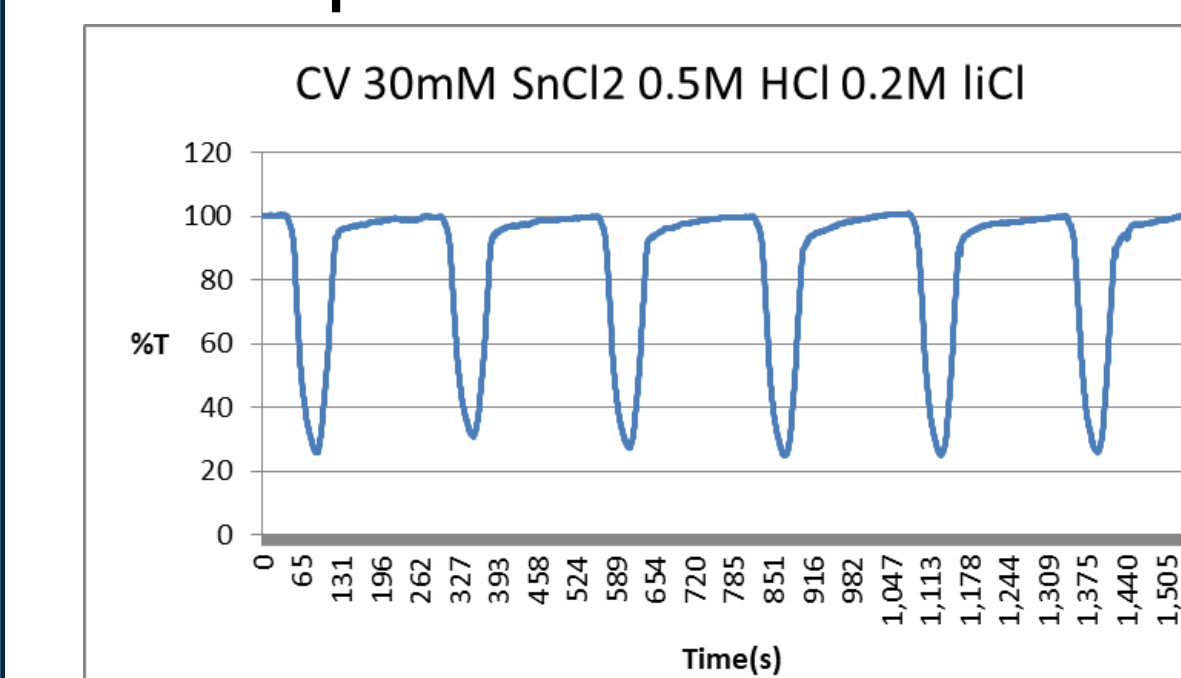
Sulfuric acid also has two main benefits. Electrolytes with this acid were much more stable and uniform in both transparency and CV cycles. Systems using sulfuric acid also used slightly more current which resulted in a slightly darker plate. Its drawback which led to us focusing on hydrochloric systems is that the electrolytes showed a reduction in reversibility not allowing the window to get fully clear.

CV of a 5mMBiCl3 0.5MH2SO4 0.48MLiCl system.



Tin Electrolyte

The Tin electrolyte system was the second path we investigated. This system uses Tin (II) chloride as its active compound which can both oxidize to tin (IV) and reduce to tin metal. This system is also a lot less complicated being able to get good results and not be as particular as the bismuth system. It can



function without lithium chloride at all, but lithium chloride greatly helps the system in both plating, reversibility, and stability. This system is immediately clear in an acidic solution as it rapidly dissolves in both sulfuric and hydrochloric acid. This system also has the added benefit of very possibly not

needing a reduction half of the window due to the formation of tin (IV). The iron chloride used in the bismuth system actually slightly decreases the palatability and reversibility of the process. We also found that the bismuth and tin systems are incompatible with each other as our attempts to make a compound system resulted in drastic reductions in stability, palatability, and reversibility.

Acknowledgments

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Conclusions

Both electrolyte systems hold great potential for future windows, and the discovered interactions can help further electrolyte research in the continued development of Reversible metal electrodeposition Dynamic windows.

Future Research

With the two electrolyte systems the next step is to go on to construct the prototype windows using them. This research will be focused on the development of the window device instead of the electrolyte.

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