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High Surface Area 3D Printed Electrodes for Electro-Organic Synthesis

Introduction

Chemicals can be prepared using a variety of different methods. The use of electricity to create chemicals, known as electro-organic synthesis, has become increasingly attractive as a sustainable and waste-reducing process. Currently, there exist few standardized options for chemists to explore electro-organic synthesis. Though commercially available platforms, such as the ElectraSyn, have been developed, these devices struggle to balance synthesis performance and accessibility. In particular, these devices are limited by the dimensions of their electrodes, which facilitate interactions between a starting chemical and electricity. Electrodes are typically composed of precious metals and are costly to scale up for larger reactions. We have addressed this challenge with 3D printing, a rapid manufacturing technique that has become increasingly accessible and is renowned for its customizability.

Methods

Electrodes were designed using Autodesk Fusion 360, 3D printed in ABS plastic and coated with conductive nickel spray paint. Initial electrode designs were modeled after traditional rectangular-shaped electrodes, with later designs incorporating high surface area geometries. The electrodes were evaluated on their ability to oxidize benzyl alcohol into benzoic acid. This model reaction was monitored using High-Performance Liquid Chromatography (HPLC) to quantify the amount of benzoic acid synthesized over time.

Results

Several electrodes were designed that significantly increased the yield of benzoic acid, upwards of two orders of magnitude greater than a traditional pure metal electrode setup. Moreover, we demonstrated the efficacy of the oxidation reaction conducted on a benchtop power supply, as opposed to using a far more costly potentiostat or ElectraSyn, the current prevailing platforms for electro-organic synthesis.

Conclusion & Relevance of the Study

Our work establishes a foundation for cost-effective and accessible methods for organic chemists to utilize electro-organic synthesis. In addition to these advantages, the electrodes, by virtue of being 3D printed, can be further modified to be compatible with virtually any experimental apparatus. The streamlining of electro-organic synthesis in this way may be critical in developing more sustainable protocols in the synthesis of important molecules used in pharmaceuticals and consumer products, among others.