Synthesis and Use of Robust Cobalt (II) Catalysts for the Reduction of CO2 to CO

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The reduction of carbon dioxide (CO2) to energy rich molecules can reduce our dependence on fossil fuels and aid in limiting CO2 levels in the atmosphere. One aspect of these efforts involves the search for homogeneous metal complexes that can electrochemically reduce carbon dioxide actively, efficiently, and selectively. Prior literature indicates that rhenium based catalysts accomplish this reduction effectively. However, rhenium metal is very expensive and not abundant; hence, rhenium is not economically viable. In an effort to find a more economical metal complex for the reduction of carbon dioxide, this research synthesizes eight different cobalt complexes with various attached ligands (terpy, phen, bpy-tBu) and explores them for catalytic activity to compare to the leading rhenium complex, Re(bpy-tBu)(CO)3Cl. Cyclic voltammetry of these complexes was studied in the presence of inert nitrogen gas and under carbon dioxide at a glassy carbon electrode in acetonitrile in order to measure catalytic activity. Initially obtained chloride salts of these complexes were converted to perchlorate salts by ion exchange to increase solubility in acetonitrile. Compared to the leading rhenium complex, all synthesized cobalt complexes indicated better activity per cost. The cobalt complexes [Co(terpy)(CH3CN)](PF6)2, [Co(bpy-tBu)2(CH3CN)2](ClO4)2, and [Co(phen)2(CH3CN)2](ClO4)2 exhibited 54, 75, and 100 times greater activity per cost respectively than the leading rhenium catalyst. Coupled with cobalt being 1000 times more abundant than rhenium, this research demonstrates that cobalt catalysts are more viable candidates for CO2 reduction based on economic feasibility.

Awards Won:
Second Award of $1,500