Carnegie Mellon

Materials Science and Engineering Seminar Series

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Materials Science and Engineering
Massachusetts Institute of Technology

"Electrochemical Pathways towards Sustainability"

Friday, April 2, 2010
11:30 A.M. Seminar in Scaife Hall 125

Electrochemical technologies have utility for environmentally sound metals extraction as well as electrical energy storage. This talk will touch upon both fields of use. In metals extraction the issue is the almost total reliance on carbon as a reducing agent which makes modern metallurgy intrinsically incapable of achieving sustainability. For example, it takes ½ tonne of carbon to make a tonne of steel. With annual global steel production of ~1.4 billion tonnes, this means that the steel industry consumes ~700 million tonnes of carbon producing over ~1.7 billion tonnes of carbon dioxide per year. The author advocates abandonment of today's carbon-intensive thermochemical reduction processes in favor of molten oxide electrolysis (MOE), which is the electrolytic decomposition of a metal oxide into molten metal and oxygen gas. MOE avoids the use of consumable carbon anodes and halide electrolytes; this eliminates the need for energy-intensive anode manufacture and guarantees the absence of greenhouse-gas emissions as the by-product of the metal-recovery step. Instead, tonnage oxygen is the by-product of electrolytic metal production. In the author's laboratory a variety of metals have been produced by MOE including iron, nickel, chromium, silicon, and titanium. Furthermore, MOE may even prove to be an enabling technology in human colonization of space which must rely upon *in situ* resource utilization to the fullest extent. The extraction of iron and silicon with co-generation of oxygen has been demonstrated in laboratory-scale cells charged with lunar soil simulant NASA JSC1-A. In the field of electrical energy storage, results of investigations focused on portable and stationary applications will be presented. For portable power, a suite of advanced materials that in combination offer the prospect of developing batteries capable of conferring practical electric vehicles a driving range in excess of 150 miles has been discovered. For stationary applications, new liquid-metal/molten-salt cells have shown promise for storage and delivery of colossal currents as would enable us to store off-peak power from the grid for subsequent delivery on demand during high usage periods. In all instances, the road to innovation is paved with advanced materials.

Donald R. Sadoway is the John F. Elliott Professor of Materials Chemistry in the Department of Materials Science and Engineering at the Massachusetts Institute of Technology. He obtained the B.A.Sc. in Engineering Science, the M.A.Sc. in Chemical Metallurgy, and the Ph.D. in Chemical Metallurgy, all from the University of Toronto. After a year of postdoctoral study at MIT as a NATO Fellow, Dr. Sadoway joined the faculty in 1978. The author of over 130 scientific papers and holder of 14 U.S. patents, his basic research centers on electrochemical processes in molten salts, ionic liquids, and polymers. With a markedly environmental focus his applied research is directed towards environmentally sound technologies for the extraction, refining, and recycling of metals, the development of rechargeable batteries for portable power applications, and stationary batteries with colossal current capability for storage and delivery of off-peak power. From 1995 to 2005 he held a MacVicar Faculty Fellowship, MIT's highest award for excellence in undergraduate education. In 1999 he became the John F. Elliott Professor of Materials Chemistry. In 2001 he was elected Member of the Norwegian Academy of Technological Sciences. In 2007 he was awarded the title of Honorary Professor at the University of Science & Technology Beijing.