

# DOE-ID NEPA CX DETERMINATION

## Idaho National Laboratory

### SECTION A. Project Title: New Alloy Anodes for Electrochemical Production of Advanced Materials

### SECTION B. Project Description and Purpose:

Technology Commercialization Fund (TCF) funding was recently awarded to Idaho National Laboratory (INL), with Caltrode, Inc. (Caltrode) as collaborative partners, to perform the electrochemical reduction of metal oxides to fabricate alloys for the clean energy sectors.

INL is the leading laboratory for advanced materials research, including materials synthesis by novel electrometallurgical processes. The materials research activities pertain to both nuclear and non-nuclear materials. Many INL-developed technologies have gained wide acceptance in different industries. Together with Caltrode Inc., the research teams will work to broad base the product portfolios for greater market penetration.

Caltrode, an Arizona based company actively engaged in the sale of various electrode materials, has evinced interest in working with INL to develop the new alloy electrodes as potential low-cost inert anode materials.

Direct electrochemical production of metals and alloys, from their inexpensive oxide intermediates, offers significant cost advantages over the traditional metal making processes that involve chemical/electrochemical reduction of relatively expensive metal halide intermediates. A typical oxide reduction electrochemical cell requires an anode, on the surface of which oxide ions are discharged. Although graphite has been used as the anode material of choice for a number of industrial metal-making processes, it has its own set of issues. These include a significant carbon footprint and generation of noxious/greenhouse gases, among others. For the past several decades, DOE has been supporting research and development efforts pertaining to the electrochemical reprocessing of used light water reactor (LWR) fuels. The first process, in the overall reprocessing scheme, is the electrochemical reduction of used uranium oxide to uranium metal, which is subsequently electro-refined to high-purity uranium. The global push for the development of an environmentally friendly electrochemical metal-making processes has led to the identification of platinum group metals as effective anodes. These metals have shown promise, at least in near-term applications. However, their prohibitive costs have intensified research and developmental (R&D) efforts to develop new and less expensive inert anode materials.

Recent experimental research performed in the laboratory has shown promising results when a binary alloy, containing one platinum group member and another transition metal, was replaced with the monolithic platinum group metal during the electrochemical reduction of transition metal oxides in two different electrolyte systems (melts of lithium chloride and calcium chloride). Such an electrode could retain its mechanical integrity without any perceptible damage when exposed to molten salts for an extended period-of-time (up to ~100h). Besides, the electrode could be used multiple times without any significant damage and/or thinning. From a cost perspective, this electrode was significantly less expensive (~ one-tenth of the cost of a monolithic platinum group metal).

The objective of this project is to use the binary alloys of molybdenum, tantalum, titanium, and ruthenium to perform the electrochemical reduction of metal oxides to fabricate alloys for the clean energy sectors. The specific objectives are three-fold: (1) preparation of alloys of titanium, tantalum, and rare earth elements from their mixed oxide intermediates; (2) refining of the oxidized waste alloys; and (3) examination of the new alloy for the electrochemical reduction of unirradiated uranium oxide.

Major tasks will include: (1) determination of the alloy composition, (2) procurement and fabrication activities, (3) electrochemical testing, (4) product analyses, (5) scale-up studies, (6) technoeconomic analysis, and (7) development of product commercialization strategies. Work will take place in the Engineering Development Laboratory (EDL, MFC-789). No equipment purchases are planned.

The major deliverables will include: (1) development of new and inexpensive inert anode materials for the clean energy sector (metal/recycling industries), (2) scale-up studies, and (3) determination of possible commercialization of the new alloys. The potential impact of the proposed technology, if successful, is going to be substantially high in terms of the development of new and cost-effective inert anode materials for producing engineering metals and alloys for a host of advanced technologies. These technologies include both the primary and secondary production of metals and alloys by an inexpensive manufacturing process.

#### Tasks

The seven tasks described below will be performed for the project. Some tasks will be completed by INL and others will involve both INL and Caltrode.

#### **Task 1:** Determination of Alloy Composition

The binary alloy compositions will be performed at INL. Initial experiments will be performed with 1:1 compositions (50% transition metal and 50% platinum group metal). Depending on the experimental results, the alloy compositions will be subsequently adjusted.

#### **Task 2:** Procurement and Fabrication

The alloy rods will be procured from an outside vendor for the testing purposes. The custom-designed alloys will be purchased from an outside vendor and may take 8-10 weeks for material delivery.

#### **Task 3:** Electrochemical Testing

Initial testing will be performed at INL to determine the ideal compositions. Subsequently, additional experiments will be performed at Caltrode.

#### **Task 4:** Product Analyses

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The evaluation and characterization of the products will be jointly performed. It is intended to perform the initial analyses of the anodes and reduced products at INL. Caltrode may be interested in repeating some of the experiments and analyses at their site. If Caltrode chooses not to repeat any experiments, then the evaluation and characterization studies will be performed at INL.

### Task 5: Scale-up Studies

Both INL and Caltrode will jointly perform this task. The scale-up studies are intended to increase the quantity of the reduced products (advanced materials). The focus will be to prepare up to 50g of the reduced alloys. Another objective is to examine the robustness of these anodes using increased amounts of oxide materials.

### Task 6: Technoeconomic Analysis

INL and Caltrode will perform this task. The technoeconomic aspects will cover the production cost of these advanced materials with the deployment of new yet cost-effective anodes. Caltrode will gather the cost numbers from the related companies to perform a comparative cost analysis.

### Task 7: Develop Product Commercialization Strategies

This task, for most part, will be performed by Caltrode. They will collect the market data for developing a possible commercialization path. INL will also provide input on possible partners who can join the effort in the commercialization efforts.

The anodes, depending on the experimental outcomes, will either be retained here at INL or they will be consumed during the experiments. It is expected that the anodes will survive and will be used in ongoing/future experimental research work.

## **SECTION C. Environmental Aspects or Potential Sources of Impact:**

### **Air Emissions**

N/A

### **Discharging to Surface-, Storm-, or Ground Water**

N/A

### **Disturbing Cultural or Biological Resources**

N/A

### **Generating and Managing Waste**

The waste will be solidified salt samples and PPE (may be industrial). No radioactive waste will be generated.

### **Releasing Contaminants**

Whenever chemicals are used there is a chance for a spill to occur.

### **Using, Reusing, and Conserving Natural Resources**

All materials will be reused and recycled where economically practicable. All applicable materials will be diverted from disposal in the landfill where conditions allow. Being conscientious about the types of materials used could reduce the impact to our natural resources.

## **SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification:** Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not

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“connected” to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

**References:** 10 CFR 1021 Appendix B to subpart D, Item B3.6, "Small-scale research and development, laboratory operations, and pilot projects"

**Justification:** The proposed R&D activities are consistent with CX B3.6 "Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed area (where active utilities and currently used roads are readily accessible). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment."

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act)       Yes     No

Approved by Jason L. Anderson, DOE-ID NEPA Compliance Officer on: 12/13/2021