IGEM Grant Report

☐ Progress (due January 1) ☒ Annual (due July 31) ☐ Final (due August 31)

IGEM Grant # IGEM 25-007 Principal Investigator Vivek Utgikar

Submission Date July 29, 2025 Primary Institution University of Idaho

Recovery of Critical Materials from E-Waste

Section 1: Summary of project accomplishments and future plans

The pyrometallurgical process based on solid state chlorination and electrowinning of Nd from the neodymium magnet e-waste is shown below in Figure 1.

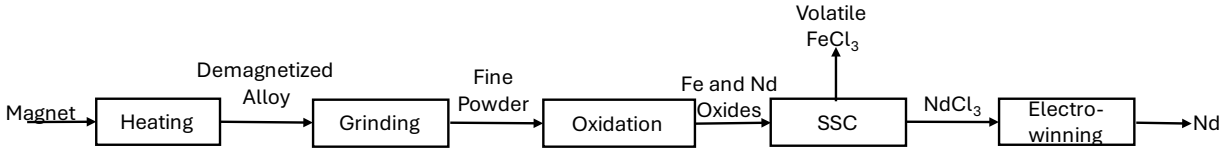

Figure 1. Process schematic for pyrometallurgical recovery of Nd

The work conducted in the reporting period focused on solid state chlorination and Fe/Nd separation with the significant accomplishments being:

1. Optimum conditions for demagnetization of the magnets have been determined.
2. Protocol for grinding of the demagnetized solid alloy in a ball mill has been finalized to obtain fine particles for processing in subsequent reaction steps.
3. Conditions necessary for complete oxidation of particles (<500 mesh or 25 μm) in a muffle furnace have been determined.
4. Processing conditions for quantitative chlorination of oxidized powder using solid NH_4Cl have been determined. Gravimetric measurements indicate that the volatile $FeCl_3$ (and other volatiles) can be selectively removed from the system yielding a solid $NdCl_3$ product that can be subjected to electrochemical reduction to obtain pure Nd.

Work planned for future includes:

1. Determination of kinetics and oxidation reactions through experimentation with uniform sized particles.
2. Electrochemical $NdCl_3$ reduction experimentation in molten LiCl-KCl eutectic electrolyte for recovery of Nd.
3. Development of comprehensive flow sheet and preliminary technoeconomic analysis

Section 2: Summary of budget expenditures

The budgeted amount for personnel costs (salary and fringe) was 62.7% of the total budget. Currently ~51% of the funds allocated have been utilized for graduate and undergraduate stipends. The expenditure is on track with the balance of funds to be used for stipends for the graduate and undergraduate students, and faculty summer salary.

The amount allocated for operating expenses was 19.2% of the total budget and currently 27% of the funds allocated in this category have been utilized for acquisition of chemicals and reagents, miscellaneous fittings, reactors and parts for experimental setup, and analysis charges. (Inclusion of the charges incurred that are in process for payment will increase this percentage slightly). The expenditures in this category are anticipated

to rise significantly, with increases in analytical charges (compositional and structural characterizations), and initiation of the electrochemical experimentation. Overall, the expenditure in this category is in alignment with the anticipated amounts needed.

The amount allocated for tuition/health insurance was 18.1% of the total budget, and currently 43.2% of the funds allocated in this category have been expended for the academic year 2024-2025. The balance of the funds will be expended over the remaining project period for the payment of tuition/insurance of the graduate student for the academic year 2025-2026 and summer semester. (The tuition/insurance charges for the academic year 2025-2026 are higher than those for 2024-2025).

Overall, the project expenditure is consistent with the anticipated spending.

Section 3: Demonstration of economic development/impact

Planned dissemination of scientific and technical advances and intellectual property development

1. Refereed journal articles on 1) review of pyrometallurgical rare earth recycle, 2) kinetics of oxidation and chlorination reactions, 3) electrowinning of Nd
2. Invention disclosure on the proposed process shown in Figure 1.

Companies identified for collaboration: U.S. Critical Materials Corporation, Idaho Strategic Resources, Inc., Megado Minerals Limited. Contacts will be initiated in late 2025/early 2026.

Section 4: Number of faculty and student participants

1. Vivek Utgikar, PI, faculty: Project management and supervision of research effort; Approval of experimental design, and guidance on data interpretation and analysis; Budget and expenditure management.
2. Krishnan Raja, co-PI, faculty: Supervision of research effort; Assisting PI in directing experimental effort and data interpretation/analysis.
3. Dijina Asarinte Valappil, graduate student: Execution of project tasks including experimentation, theoretical modeling, sample analysis and data interpretation.
4. Diba Zadehgol, undergraduate student: Assisting graduate student in conducting experiments and laboratory tasks.
5. Mahir Adib, undergraduate student: Assisting graduate student in conducting experiments and laboratory tasks.

Section 5: Long term sustainability and future plans

Follow up research will focus on optimization studies on the process steps investigated in this research as well as incorporating processing steps for the management of secondary stream generated in each step. Process flow sheet will also be modified to include head-end e-waste processing schemes. Finally, theoretical models will be developed to increase fundamental understanding of the transformations in the process.

Potential funding agencies: 1) ARPA-E 2) NSF (CBET Division and cross-cutting programs), 3) DOE – Critical Materials and Minerals Programs, SBIR/STTR

Section 6: *Expenditure Report*

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Expenditures

Category	*Budgeted*	*Spent*	*Balance*
Personnel (Salary + Fringe) PI, co-PI, Students	*87,752*	*45,048.07*	*42,703.93*
Operating Expenses (Materials/Supplies, Publication)	*26,832*	*7,246.70*	*19585.30*
Graduate Tuition and Health Insurance	*25,416*	*10,991*	*14,425.00*
Total	*140,000*	*63,285.77*	*76,714.23*