# Exploring Hydrothermal Leaching for Selective Metal Recovery from Spent DeNOx catalysts

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Hydrothermal leaching (HTL) is an emerging technology that utilizes subcritical water conditions to selectively extract valuable metals from complex solid waste matrices, where traditional processes often fail to achieve high selectivity or environmental compatibility. Compared to conventional leaching methods, HTL offers enhanced reaction kinetics and promotes the breakdown of organics under moderate temperature and pressure. The HTL approach is particularly well-suited for spent DeNOx catalysts from selective catalytic reduction (SCR) units, which are of increasing concern due to their widespread use in flue gas treatment systems and their rich content of critical raw materials (CRMs) such as vanadium (V), tungsten (W), and titanium (Ti). These catalysts represent a challenging matrix due to their refractory nature and strong metal-support interactions.

This study compared alkaline HTL and acidic leaching under oxidizing conditions, and explored their combination via a sequential leaching strategy for selective extraction of V, W, and Ti from SCR samples (1.61, 3.63, and 44.3 wt.%, respectively). HTL experiment was performed at 250 °C and 40 bar with 3 M NaOH for 120 minutes, while L used 15% sulfuric acid and sodium sulphite (as an oxidant) at 90 °C for three hours at atmospheric pressure. The SL method combined both steps to enable efficient and selective metal recovery, offering a sustainable approach.

Experimental results demonstrate that HTL significantly outperforms conventional acid leaching, achieving recoveries above 99% for V and W, while Ti remains largely in the solid phase. This highlights the effectiveness of thermal activation in enhancing metal solubility. Acid leaching efficiently and selectively recovered 94% of the vanadium. SL approach was employed to enable selective extraction by first recovering V through acid leaching, followed by HTL treatment to extract W from the residue. This integrated approach combines the strengths of both methods, bringing together HTL's enhanced metal solubility under moderate conditions and low reagent consumption with the selectivity of acid leaching. The result is an efficient, scalable, and sustainable solution for selective metal recovery, aligned with the circular economy principles and sustainable waste management.

**Keywords**: *Hydrothermal Leaching, Critical Raw Materials, Circular Economy, SCR Catalysts, Titanium.*