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Upcycling of Ni(II) from electroplating wastewater to plasma NH_3 synthesis catalysis

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Treating heavy metal Ni(II) ions from the electroplating industry is mandated word-wide. After multi-stage treatment processes, the Ni(II) concentration in wastewater can reach between a few ppm to several tens of ppm, which still does not meet the national permitted discharge standards. Adsorption is considered to be an effective method for treating low concentration nickel due to its low cost, eco-friendliness, and high processing efficiency. MCM-41 zeolites have been used for the removal heavy metal ions in wastewater due to the uniform pore size distribution, excellent transports properties, and high flexibility for surface modification. Traditional chemical impregnation can effectively improve the chemical composition of MCM-41 and adsorption efficiency, it also causes pore blockage and decreased specific. Nanosecond pulse discharge modification technology can increase the specific surface area through plasma cleaning and pore-making effects, and implant oxygen-containing functional groups under the action of strong oxidizing radicals. Therefore, the combination of chemical impregnation with plasma modification can improve the physical structure and chemical composition, and enhance the adsorption capacity for heavy metal ions.

Rather than regarding Ni(II) as a disposable waste, the chemicals industries could instead consider it a huge resource. Research shows that Ni(II) based catalysts have significant effects in plasma catalyzed NH_3 synthesis. Therefore, in this study, we prepared a porous zeolites rich in functional groups as an excellent adsorbent for the removal of Ni(II) ions using nanosecond pulse discharge-amino co-functionalization method. The adsorbed nickel catalyst was calcined to prepare a Ni(II)-based catalyst for plasma-catalyzed NH_3 synthesis. It was found that the nanosecond pulse discharge-amino co-functionalization enables the zeolites to achieve 98% of Ni(II) ions removal efficiency. The residual Ni(II) ions concentration in solution was well below national permitted discharge standard for Ni(II). The excellent adsorption capacity is mainly due to the high porosity, the increase in specific surface area, and the existence of high concentration -NH_2 and -COOH. The highest NH_3 synthesis rate of 1200 μmol/h was achieved using Ni/MCM-41, which was four times higher than that obtained using plasma only. This strategy of upcycling metal waste into functional, catalytic materials offers a multipronged approach for clean and renewable energy technologies.

References

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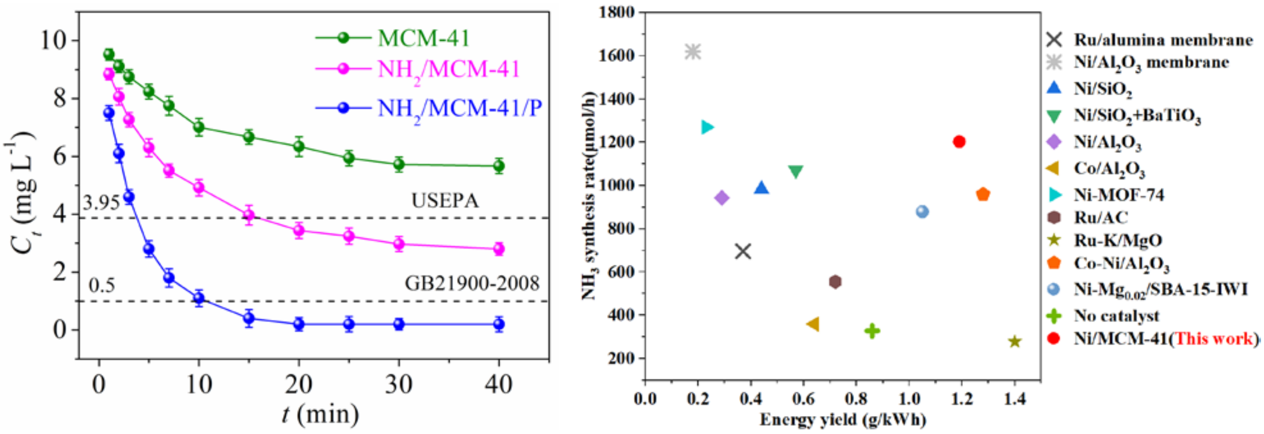

Figure 1. Residual Ni(II) concentration in solution as a function of adsorption time (left) and Reported NH3 synthesis rate vs energy yield in the plasma-catalytic NH_3 synthesis using DBD.