I.1: Nickel hydroxide derived from spent electroless nickel bath as a potential electrode material for supercapacitors

For centuries metals have played crucial role in our day to day life due to their durability, strength and versatility. However, utilization of these metals is accompanied by many challenges, one of them is metallic corrosion. Multiple solutions are available for enhancing metallic corrosion resistance. Among these solutions, metal surface coating is one of the most cost effective and convenient corrosion protection methods. Electroless nickel (EN) deposition is one type of coating, which provides good corrosion resistance to the base substrate. EN coating involves deposition of nickel phosphorus (NiP) alloy instead of pure metallic nickel on the substrate without passage of electric current. Electroless nickel plating is a routine activity carried out in Chemical Treatment Lab (CTL) on various components that is being used in lasers and accelerators to meet specific functional requirements. Some of the important components that were deposited with EN include bread boards of Petawatt laser, magnet components, bus bars of laser power supplies, water headers and heat sinks used in accelerator power supplies.

EN plating technique also offers good wear resistance, lubricity, solderability and magnetic properties. This process produces a Ni-P coating of uniform thickness even on complex shaped components as no passage of electric current is involved. However, the conundrum associated with this feasible plating technology is the limited lifespan of electroless nickel plating bath. The solution has to be replaced after completion of six metal turn over from a given volume of solution. Once the electroless nickel bath is no longer productive, it is removed from the production line and sent for treatment. The normal procedures adopted for the treatment of waste plating baths are hydroxide precipitation, catalytic decomposition and electrolytic plate out. As the name suggests, hydroxide precipitation treatment method involves precipitation of nickel metal ions from the electroless nickel bath as nickel hydroxide $Ni(OH)_2$ at an elevated pH level. The process is simple and effective, but generates large amounts of solid wastes, which is then used in land filling or dumped into grounds. This adds extra cost towards handling and storage and thus, makes the cost of the procedure exorbitant.

With the recent advances in nanotechnology, hydroxides and oxides of nickel have found applications in electrochemical devices like sensors, batteries and supercapacitors. High theoretical capacitance (2358 $F.g^{-1}$), excellent electrochemical properties, stability in alkaline medium and less toxicity makes nickel hydroxide an ideal candidate for supercapacitor electrode material.

Different nickel hydroxide synthesis procedures have been reported in the literature. However, most of them require special reaction conditions, costly equipment and chemicals. In this article, effective chemical treatment of spent electroless nickel bath and utilization of the generated plating waste as an active electrode material for supercapacitors is reported.

The chemical synthesis of nickel hydroxide from spent electroless plating bath is carried out using a simple precipitation reaction as shown in Figure I.1.1(a). The resulting plating waste is then washed with de-ionized (DI) water and dried in hot air oven at 70 °C to obtain green coloured nickel hydroxide powder as shown in Figure I.1.1(b), which is used for further chemical analysis. The electrochemical characterization of the nickel hydroxide is carried out using cyclic voltammetry (CV) and galvanostatic charge and discharge (GCD) technique as shown in Figures I.1.1(c) and I.1.1(d).

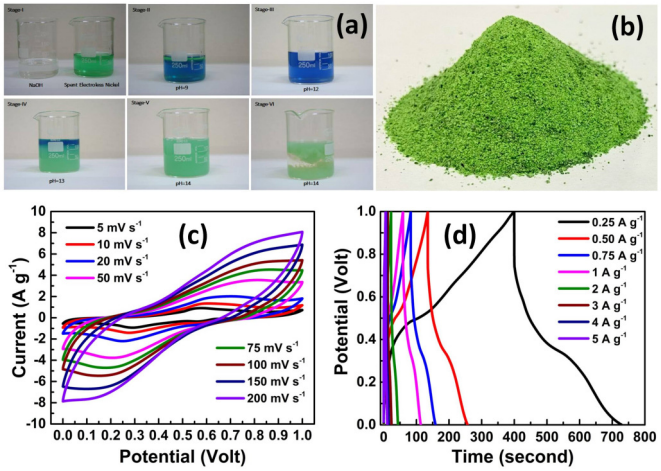

Fig. I.1.1: (a) Different stages of nickel hydroxide precipitation from spent electroless nickel bath, (b) powdered nickel hydroxide, (c) cyclic voltammogram, and (d) glavanostatic charge discharge profile of symmetric nickel hydroxide supercapacitor.

Nickel hydroxide obtained from spent electroless nickel bath shows specific capacitance of 332 $F.g^{-1}$ with energy density of 11.52 $Wh.kg^{-1}$ and power density of 207.5 $W.kg^{-1}$. The findings of this research will help in utilization of the waste material for sustainable energy storage development.

Reported by:
P. Ram Sankar (prs@rrcat.gov.in)