

Nickel Foam as an Electrode Substrate: Preparation, Loading, and Applications

How to prepare nickel foam for battery and supercapacitor electrode research: cleaning, activation, active material loading methods, and the key specifications that affect your results.

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Why Nickel Foam?

Nickel foam occupies a specific and well-established niche in electrode research. It is not the right substrate for every application, but for the applications where it fits, it is difficult to replace.

The defining characteristic of nickel foam is its three-dimensionally interconnected open-cell structure. This architecture gives you two things simultaneously: **high electronic conductivity** (pure nickel, bulk conductivity around 14 MS/m) and **high accessible surface area** (specific surface area of 110 PPI foam typically around 0.04–0.06 m²/g geometric, with the macroporous structure enabling infiltration of active materials and electrolyte into the interior). Flat current collectors like copper or aluminum foil can only be loaded on the surface; nickel foam can be loaded through its volume.

The result is that nickel foam electrodes routinely achieve **areal capacities and loadings several times higher** than equivalent flat-foil electrodes, without the thick-electrode ion-transport limitations that often cap practical loading on flat substrates.

Key Applications

Supercapacitor Electrodes

This is the original and most common application for nickel foam in research. For pseudocapacitive materials—NiO, Ni(OH)₂, Co₃O₄, MnO₂, NiCo-LDH, and related compounds—nickel foam provides the conducting scaffold for the active material, which is deposited by hydrothermal synthesis, electrodeposition, or slurry coating directly on and into the foam. The open pore structure allows electrolyte (typically aqueous KOH) to access the active material throughout the electrode volume, enabling high pseudocapacitive utilization.

For carbon-based double-layer supercapacitor electrodes (activated carbon, carbon nanotubes, graphene), nickel foam is a convenient substrate for pressed or slurry-coated electrodes where the foam's mechanical rigidity is useful during cell assembly.

Battery Electrodes (NiMH and Ni-Cd)

Nickel foam was originally developed as the electrode substrate for nickel-metal hydride (NiMH) and nickel-cadmium (Ni-Cd) batteries, where $\text{Ni}(\text{OH})_2$ is the active material. In commercial NiMH cells, the positive electrode is still manufactured using nickel foam to this day. For research on new NiMH electrode materials or electrolyte additives, nickel foam is the appropriate reference substrate.

Lithium Battery Anodes and 3D Current Collectors

For lithium plating studies—relevant to Li-metal anode research and some solid-state battery configurations—nickel foam provides a high-surface-area substrate that distributes lithium deposition more uniformly than flat copper foil. The three-dimensional deposition tends to reduce dendritic growth at a given current density compared to planar substrates.

For high-loading composite anodes (silicon-carbon, for example), nickel foam can serve as the current collector when the active material is infiltrated by slurry coating under vacuum.

Fuel Cell Gas Diffusion Layers and Catalysis

Nickel foam is used as a gas diffusion layer in alkaline fuel cells and as a catalyst support for oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) studies in water electrolysis. The open structure facilitates gas transport while maintaining electrical contact across the electrode.

Specifications of This Product

Parameter	Value
Dimensions	100 × 100 mm
Thickness	1.6 mm
Pore density	110 PPI
Porosity	≥ 95%
Average pore diameter	~160 μm
Material	Pure nickel, Ni ≥ 99.7%
Pack sizes	1 sheet or 2 sheets

What 110 PPI Means

PPI (pores per inch) describes the pore density. At 110 PPI, the pore diameter is approximately 160 μm—small enough to provide a fine network for active material support, but large enough that the pores do not close up when loaded with typical active material amounts (1–5 mg/cm²). For applications requiring even finer structure, 120–130 PPI foam is available on request. For applications where electrolyte diffusion into a thick active material layer is the primary concern, lower PPI (60–80 PPI) with larger pores may be more appropriate.

Purity and Its Implications

At 99.7% purity, the main impurities are trace amounts of Fe, Co, and C. For most electrochemical research, this purity is more than adequate. For studies specifically examining nickel corrosion or nickel dissolution into the electrolyte as a contamination mechanism, higher purity nickel foam (99.9%+) is available on request.

Preparation Before Use

As-received nickel foam has a thin surface oxide layer and may have residual lubricant or organic contamination from the manufacturing process. Depending on your application, some or all of the following steps may be necessary.

Step 1: Cutting to Size

Cut the foam to your electrode dimensions using sharp scissors or a die punch. Dull scissors compress the foam structure near the cut edge rather than cutting cleanly, which can close pores at the electrode perimeter and create irregular edge geometry. For electrodes used in coin cells or small pouch cells, typical sizes are 1–2 cm diameter circles or 1–2 cm squares.

Always cut before cleaning—the cutting operation itself introduces contamination that the cleaning step will remove.

Step 2: Degreasing

Soak the cut foam in acetone for 15–30 minutes in an ultrasonic bath. Acetone removes organic surface contamination including residual lubricants and fingerprint oils. Replace the acetone and repeat if the foam visibly discolors the solvent.

Follow with an ethanol rinse, then a deionized water rinse. At each step, brief (2–5 minute) sonication improves cleaning efficiency without damaging the foam structure.

Step 3: Acid Activation (If Required)

For applications where the surface oxide is problematic—particularly electrodeposition and some hydrothermal synthesis protocols—treat the foam in 3 M HCl for 15–30 minutes at room temperature. This removes the nickel oxide layer and exposes the bare metallic nickel surface.

After acid treatment, rinse immediately and thoroughly with deionized water, then with ethanol, then dry under nitrogen or in a vacuum oven at 60°C. Do not allow the acid-treated foam to dry in air before rinsing, as the surface will re-oxidize rapidly when wet with residual acid.

Note: acid activation is not necessary for slurry-coated electrodes where the conductive carbon additive in the slurry provides the contact path. It is primarily relevant for direct electrodeposition of active materials onto the nickel surface.

Step 4: Drying

Dry the cleaned foam at 80–100°C in a vacuum oven for at least 2 hours before weighing or active material loading. Residual moisture in the foam pores will cause errors in mass loading calculations and can interfere

with some deposition methods.

Weigh the dried foam immediately after removal from the oven, before it equilibrates with ambient humidity.

Active Material Loading Methods

Slurry Coating

The simplest method: prepare a slurry of active material + conductive carbon (typically 10–15 wt% Super P, Ketjenblack, or similar) + binder (PVDF in NMP for non-aqueous, CMC/SBR in water for aqueous), then apply by drop-casting, doctor blade, or painting onto the foam surface.

For nickel foam, thin slurries (lower viscosity) infiltrate the foam structure better than thick slurries. A typical approach is to apply a thin coat, dry at 80°C, and repeat until the target mass loading is reached.

After drying, press the loaded foam gently (5–10 MPa) with a flat die to improve contact and reduce thickness variation. Excessive pressing collapses the foam structure and eliminates the benefit of the three-dimensional substrate.

Hydrothermal Synthesis

For nickel-based pseudocapacitive materials ($\text{Ni}(\text{OH})_2$, NiO , NiCo-LDH), hydrothermal synthesis directly on the foam surface produces active material that is intimately bonded to the substrate—better electrical contact than slurry-coated material, and no binder required.

Typical protocol: clean nickel foam is placed in a Teflon-lined autoclave with the precursor solution, heated at 120–180°C for 6–24 hours, then rinsed and dried. The foam acts as both the substrate and, in some protocols, the nickel source for the active material.

Electrodeposition

For thin-film active materials where precise thickness control is needed, electrodeposition onto acid-activated foam provides conformal coatings on the three-dimensional surface. Particularly useful for NiO , $\text{Co}(\text{OH})_2$, and MnO_2 .

Mass Loading and Calculation

Mass loading (mg/cm^2) is the standard figure of merit for comparing electrode performance across different studies. Calculate it as:

$$\text{Loading} = (\text{mass after} - \text{mass before}) / \text{electrode area} (\text{cm}^2)$$

Measure the electrode area as the geometric footprint (length $\times$ width for a rectangle, πr^2 for a circle), not the BET surface area. This is the convention used in the literature, and it is what allows comparison with other published results.

Typical ranges: 1–3 mg/cm^2 for supercapacitor electrodes targeting high volumetric performance; 3–10 mg/cm^2 for electrodes targeting maximum areal capacity.

Storage and Shelf Life

Store unused nickel foam sealed in the original packaging at room temperature. The natural oxide layer that forms on nickel in air is self-limiting and does not affect performance for most applications. Nickel foam does not require special atmosphere storage.

Avoid storage near strong acids, halogens, or other corrosive chemicals—even the vapor phase can initiate localized corrosion on the foam surface over extended periods.

Related Products

- [CR2032 Coin Cell Kit](#) — for testing nickel foam electrodes in a standard coin cell format
- [Aluminum Laminated Film](#) — for pouch cell assembly with nickel foam electrodes
- [XRD In-Situ Cell](#) — for operando characterization of electrode structure changes during cycling

Enquiries: business@labcorematerials.com · labcorematerials.com

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