METHOD FOR MAKING NANOMETER THIN SHEETS OF METALS IN AIR

IITM Technology Available for Licensing

Problem Statement

- Molecular interactions at liquid-air interfaces were studied from **Agnes Pockels times**.
- Assembled structures at these interfaces have contributed to understanding **2D films**, even with diverse materials like **nanoparticles**.
- Stable molecules and particles arrange at interfaces due to **surface tension**. The **direct creation of nanostructures** is possible at interfaces using **atomic precursors**.
- Methodologies for metal nanoparticles (NPs) on solid surfaces with **ambient electrolytic spray and electrospray** is adapted for liquid surfaces, allowing **synthesis & assembly**.
- An **electrical double layer** at the liquid-air interface, along with its response to moderate **electric fields,** can induce motion in both surface and bulk liquid, guiding suspended NPs into **organized arrangements**.
- Traditional methods to create **thin metal sheets** in vacuum conditions use thermal and electron beam evaporation, and magnetron sputtering, but require **high vacuum, sophisticated tools**, and **elevated temperature.**
- Thus, there is a need for a new method that can address the above mentioned issues. The present invention introduces an **ambient method for creating thin metal films**.

Technology Category / Market

Technologies: Chemistry & Chemical Analysis, Micro & Nano Technologies

Application: Catalysis & Catalytic Conversion, Photovoltaics, Gas Adsorption, Energy Storage and Energy conversion, Electrochemistry, Coating .

Market: The global sheet metal market size was valued at **US$ 262.2 B in 2019** and is expected to grow by **5% CAGR from 2020 to 2025**.

Industry: Chemical/Catalysts Manufacturing, Chemical Analysis, Instrumentation, Automotive and Aerospace, Electronics, Nanotech, Pharmaceutical and Biotechnology, Nanoelectronics Technology, Environmental Technology.

Technology

The present patents core idea is producing **nanometer-thin metal films on liquids without vacuum or high temperatures.**

Key Features / Value Proposition

❖*User Perspective:*

- **Simple & Versatile:** Easy to use method, allowing users to create nanometer-thin metal sheets with a variety of metal precursors & liquids as needed.
- **Efficient Catalysis:** The nanosheets serve as effective and reusable catalysts, improving efficiency of chemical reactions & promoting sustainability.
- **Diverse Applications:** The nanosheets find applications in catalysis, sensors, electronics, and energy storage, enabling users to explore a wide range of possibilities.

❖*Technology Perspective:*

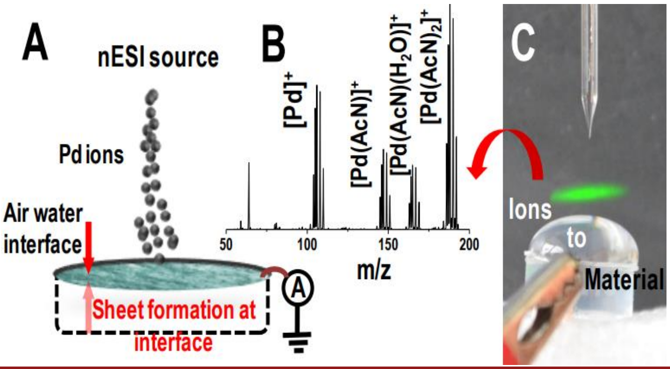
- **Ambient Synthesis:** The technology creates nanosheets without the need for high vacuum or extreme temperatures, simplifying the process and enhancing scalability.
- **Material Flexibility & Controlled Self-Assembly:** Nanosheets of different metals & alloys, are formed through precise electrospray-driven self-assembly, resulting in structured & consistent properties for various applications.

❖*Industrial Perspective:*

- Industries benefit from a **cost-efficient** process, avoiding complex equipment & high-energy needs.
- Nanosheets enhance **reaction rates** & selectivity, **valuable** for industries reliant on catalysis.
- **Market Diversification:** Industries can expand product portfolios with nanosheets, exploring new markets and applications for innovation.

Fig 1 illustrates:

a. schematic of electrospray deposition of $PdCl_2$ on water surface,
b. mass spectrum of $PdCl_2$ solution in acetonitrile, using nESI source,
c. optical image of electrospray deposition at air-water interface.



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Method

This is achieved by **depositing nanometer-scale droplets onto liquid surfaces under the influence of an electric field.**

With this objective, experiments are done by which **NPs of Pd^{+}** were synthesized on the surface of water reservoir that is self-assembled to form **nanoparticle-nanosheets**. **Fig 1, 2.**

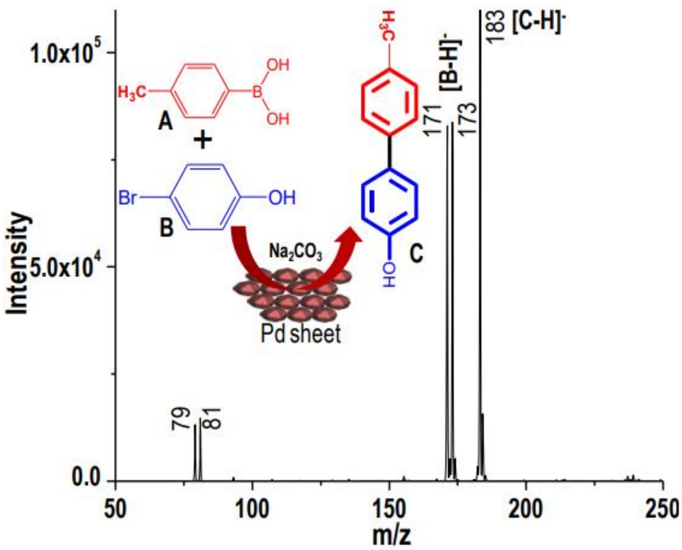

Fig 2 illustrates: Mass spectrum collected after Pd NP-NS catalyzed coupling reaction between 4-tolylboronic acid and 4-bromophenol; inset shows the structures of the reactants and the product.

A method of making nanometer thin, **<100 nm free standing 2D metal sheets at air-liquid interface -** the said **method comprises**:

- **at least one metal salt precursor dissolved in a solvent;**
- **electrospraying of the solvated metal salt precursor at a voltage 1000-2000 V from 10-15 mm distance over the liquid surface;**
- **gently depositing nanometer scale droplets over the liquid surface at room temperature, which are then self- assembled to form nanoparticle-nanosheets.**

Wherein, the **charged metal ion reduced to neutral metal atom** without using **any external reducing agents** during the course of deposition, that aggregates to form **nanoparticles** at the **interface** and **arrange** to form nanoparticle-nanosheets over the liquid surface.

Wherein

- The **metal** is **palladium** and the **metal salt** is **palladium chloride**.
- The **metals** are selected from various **salts** of **gold, silver, platinum, palladium, nickel and copper.**
- The **thin film** is made of different **alloys including silver-palladium and gold-palladium.**
- The **solvent** of the **precursor solution** includes **methanol, ethanol, water, acetonitrile and combination** thereof with different proportions.
- The **liquid reservoir** contains liquids including **water, ionic liquid and ethylene glycol.**
- The **liquid reservoir** contains **liquid metals or semiconductors** which are solids at room temperature.
- The **electrospray deposition** of **films** occurs along with other stimuli including **light, temperature and magnetic field.**
- The **modification** of the **electrospray** occurs during solvent evaporation of the droplets using **temperature, light, electric & magnetic fields.**
- The **thin metal films** are used as a **catalyst, sensor, gas adsorbing medium and electrodes for electrochemical reactions.**

Intellectual Property

IITM IDF Number: 1594
IP Patent Number: 332623 (Granted)
PCT/IN2018/050654

TRL (Technology Readiness Level)

TRL – 4; Technology validation in Lab

Research Lab

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