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Precipitation of Platinum Group Metal Nanoparticles in Bioinspired Systems

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Platinum group metals (PGMs), including platinum, palladium, and rhodium, are essential for industrial applications due to their unique catalytic, electrical, and physical properties. As a consequence of high demand for these metals, and the declining natural sources, they are classified as critical raw materials. One of the largest secondary resources of PGMs can be the automotive industry, incorporating these metals into automotive converters to neutralize volatile organic compounds and nitrogen oxides (NO_x). From the standpoint of a circular economy and environmental sustainability, it is crucial to search methods for the reuse and safe application of these materials in a manner that is environmentally responsible. This research represents a preliminary study on the search for new method of precipitating PGM nanoparticles, which represents a sustainable and renewable resource-based strategy in line with future technologies of bio-inspired systems.

The precipitation of PGM nanoparticles was carried out in the presence of saponins, rhamnolipids (*soapnuts, Quillaja bark, rhamnolipids JBR 425*), and ascorbic acid-vitamin C (AA), natural substances with reducing properties. The purpose of the research was to study the impact of the presence of natural reducing agents and pH regulation (~7) with Na_2CO_3 on the effectiveness of the PGM precipitation reactions. In order to achieve this goal, four test systems were created with the following parameters:

- group I: PGMs precursor + saponin/rhamnolipid + AA,
- group II: PGMs precursor + saponin/rhamnolipid,
- group III: PGMs precursor + saponin/rhamnolipid + AA + pH regulation,
- group IV: PGMs precursor + saponin/rhamnolipid + pH regulation.

The samples were analysed using atomic absorption spectroscopy (after 1, 24, 48, 168 h of precipitation) and UV-VIS spectroscopy (1, 168 h). It was observed that the use of a pH-regulation agent enhanced the efficiency of the reaction of PGM nanoparticle precipitation. In samples with pH elevated to approximately 7, the efficiency of Rh, Pd, and Pt nanoparticle precipitation exceeded 68, 78, and 87%, respectively. It can be seen that the addition of AA has also a beneficial effect on efficiency. The most favorable outcomes, with 100% efficiency, were observed in the following systems:

- $PdCl_2$ + saponin (Quillaja bark + AA + pH control
- $PdCl_2$ + rhamnolipid (Rhamnolipids JBR 425) + AA + pH control

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