Synthesis and Characterisation of Carbon Materials

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Unlocking the potential of pine sawdust biochar for adsorption of Co(II) and Ni(II) ions and sustainable recycling for carbamazepine removal

Anna Yukhymchuk [1], Daria Zhukova [1], Nataliia Prybora [1], Nataliya Stolyarchuk [2], and Inna Melnyk [3,]*

[1] Natural Faculty, Department of Chemistry, Dragomanov Ukrainian State University, 9 Pyrohova, Kyiv 01601, Ukraine
[2] Department of Chemisorption and Hybrid Materials, Chuiko Institute of Surface Chemistry, National Academy of Sciences of Ukraine, 17 Generala Naumova, Kyiv 03164, Ukraine
[3] Department of Physical and Physico-Chemical Methods of Mineral Processing, Institute of Geotechnics, SAS, 45 Watsonova, Košice 04001, Slovak Republic

* Corresponding Author: melnyk@saske.sk

Eurostat's 2020 data reveals that the EU produced approximately 2.135 billion tonnes of waste, averaging 4.815 kg per capita. About 59.1% of this waste was recovered through recycling, backfilling, or energy-producing incineration, while 40.9% was disposed of through landfilling or non-energy producing incineration. The figures underline significant waste generation and recovery efforts within the EU. Further research emphasizes the importance of responsible waste management, particularly with pine-related waste, in environmental sustainability. Various studies explore the potential of pine waste in applications like odor control in waste treatment and as biochar for pollution control and water treatment, showing its utility in sustainable practices. Additionally, the treatment of persistent pollutants like carbamazepine using innovative photocatalytic methods highlights ongoing challenges and the need for effective environmental remediation strategies.

The study successfully showcases how waste from pine tree sawdust can be repurposed into a versatile biochar, serving as a tool for environmental clean-up efforts. Utilizing leftover plant materials from *Pinus sylvestris*, a sustainable form of biochar with superior qualities for adsorbing Cobalt(II) and Nickel(II) ions from water has been engineered.

The biochar's composition, architecture, and surface properties were thoroughly examined through a battery of physicochemical techniques including SEM, TEM, XRD, and FTIR spectroscopy. These investigations revealed the biochar's intricate structure and vast surface area, both essential to its remarkable ability to adsorb pollutants.

Additionally, the study tackles the pressing issue of managing pine waste by transforming it into a valuable resource for water purification methods. The biochars produced showcase outstanding capabilities for heavy metal ion adsorption and are also effective in breaking down stubborn pharmaceutical pollutants when exposed to UV light, thus offering a twofold strategy against water contamination.

The role of the biochar in the photocatalytic degradation of the drug carbamazepine was further explored. Findings indicated that the metal ions absorbed onto the biochar surface contribute to forming nickel hydroxide and cobalt phosphate. These substances play a crucial role in the photochemical degradation of organic compounds, suggesting that used biochars could be repurposed for photocatalytic uses.

The findings highlight the promise of pine sawdust-derived biochar in sustainable waste management. This approach effectively confronts pollution, addressing both toxic metal removal and organic pollutant breakdown in aquatic environments. Figure 1 presents all the transformations that pine-derived charcoal underwent, including cation adsorption and subsequent photocatalytic degradation of carbamazepine.

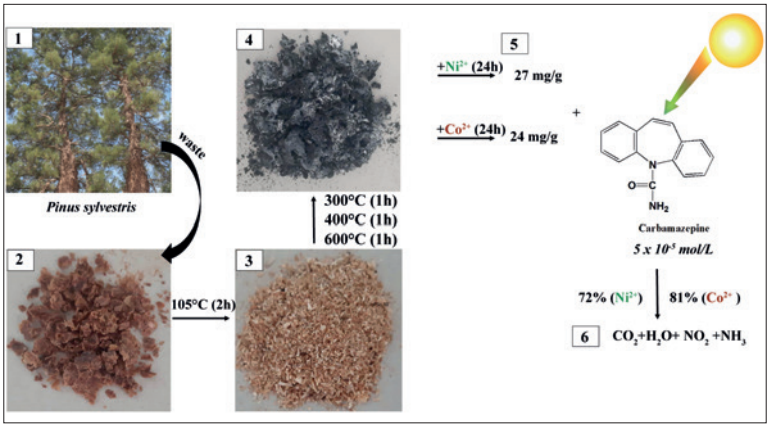

Fig. 1. Synthetic ways of obtaining biochar samples from *Pinus sylvestris* waste.

This field of study is still emerging and overlaps with multiple disciplines such as environmental engineering, chemistry, and materials science. It plays a crucial role in advancing green technologies for water purification, contributing to the overarching objective of sustainable development. As the world faces the twin challenges of environmental pollution and the demand for sustainable practices, the investigation of these innovative technologies grows increasingly important.

In conclusion, our research underlines the need to develop economical, sustainable, and effective waste treatment and environmental conservation techniques. It advocates for the transformation of biomass waste into valuable substances for environmental cleanup, in line with worldwide sustainability objectives.

Keywords: sustainable material, pine waste biochar, cobalt(II) ions, nickel(II) ions, photocatalysis, carbamazepine removal

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