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Synthesis and characterization of Cu-Ni bimetallic system for its potential application in glucose biosensors

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Abstract

Diabetes is a chronic disease that has become a global health issue. Due to the annual increase in the number of diagnosed patients, there is growing interest in research works and the development of novel materials applicable to glucose biodetection. In this context, bimetallic materials are being implemented in the improvement of biosensors due to the enhanced physical and chemical properties that are provided by the combination of two related metallic elements. In this study, a copper–nickel (Cu-Ni) bimetallic system was synthesized via a hydrothermal approach, using them as precursors. The effect on different physical and chemical properties of the pH variation between 9 to 10 was evaluated while maintaining a constant temperature (140 °C), a reaction time (6 h), and a molar rate of the precursors (1:1). The synthesized Cu-Ni system was characterized by X-ray diffraction, determining diffraction peaks at 2θ angles of 44.33°, 51.62° and 76.31°, corresponding to the Ni element, and at 2θ angles of 43.34°, 50.47° and 74.23°, associated with Cu. The diffraction peaks of both metals correspond to the (111), (200), and (220) crystallographic planes of the face-centered cubic structure. Scanning electron microscopy characterzation was carried out, where the morphology analysis showed bar- and sphere-shaped particles for the bimetallic synthesized within the varied pH range. Finally, an FTIR spectroscopy analysis in the range from 400 to 4,000 exhibited absorption bands at 470 and 517, which are attributed to the bending vibrations of the Ni-O and Cu-O bonds, respectively. The obtained results support the formation of the Cu-Ni bimetallic system and provide evidence of its suitable properties for use as a receptor element in a capacitive biosensor for glucose detection.

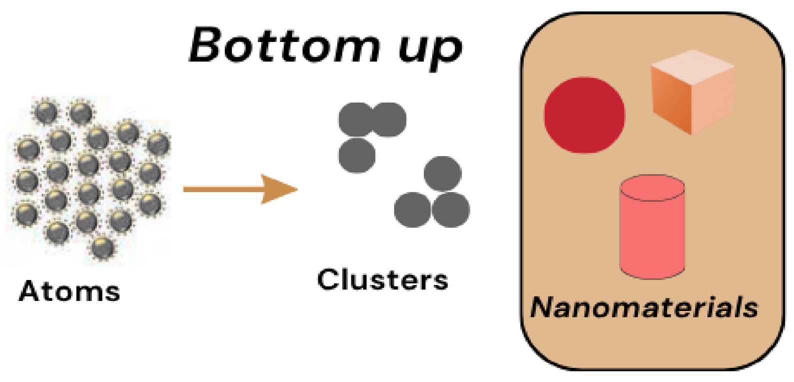
INTRODUCTION & AIM

- **In 2024, the global prevalence of diabetes reached 589 million people. (International Diabetes Federation)**
- **Bimetallic materials are used in glucose biosensor applications due to their physical and chemical properties when combining two metallic elements.**

Bimetallic materials

Aim

Synthesis and characterization of a Cu–Ni bimetallic system synthesized by the hydrothermal method, evaluating the pH parameter and its potential application as a glucose biosensor.



Properties of Cu-Ni bimetallic material

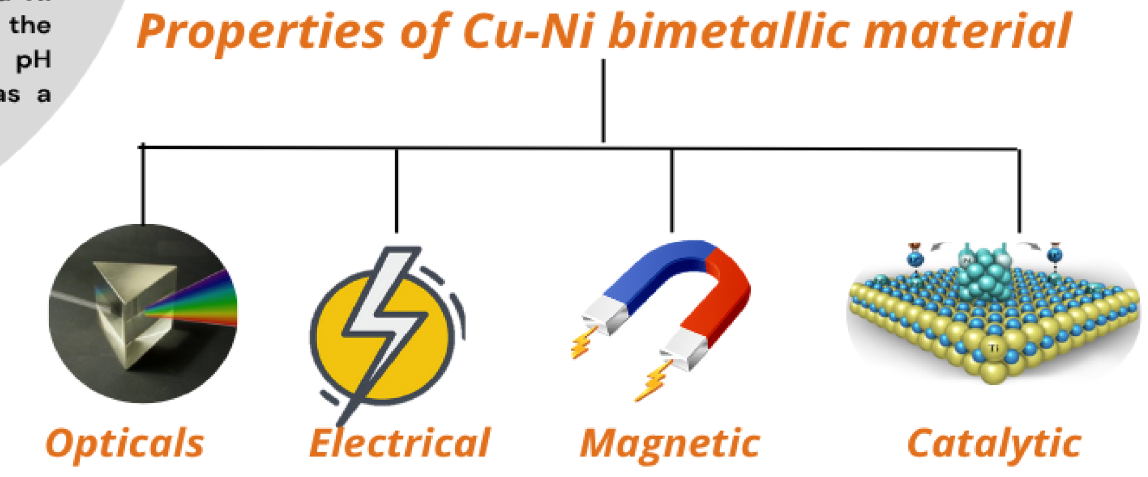


Figure 1. Importance of bimetallic nanomaterials.

METHOD

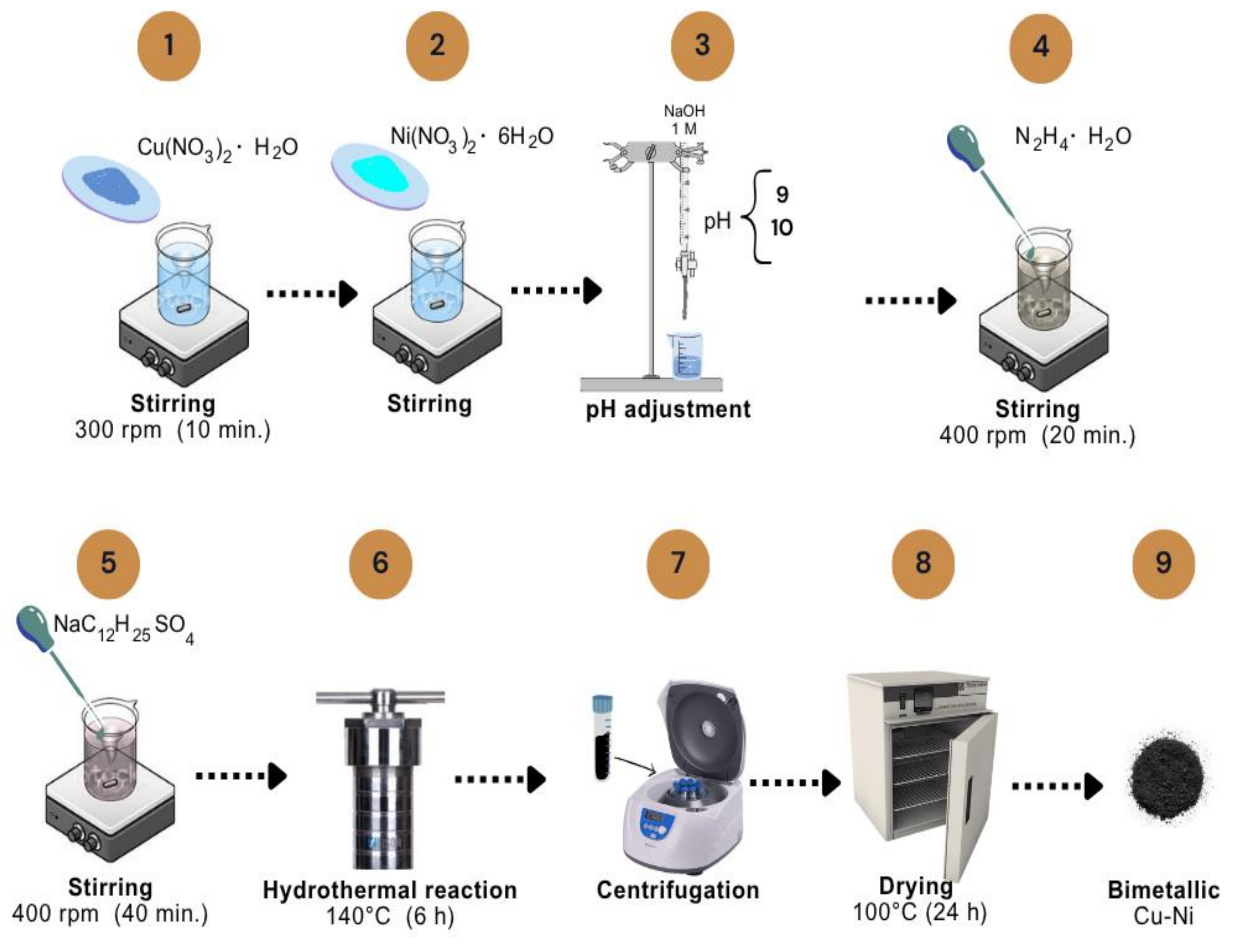


Figure 2. Experimental methodology for the synthesis of the bimetallic material Cu-Ni.

RESULTS & DISCUSSION

X-ray diffraction

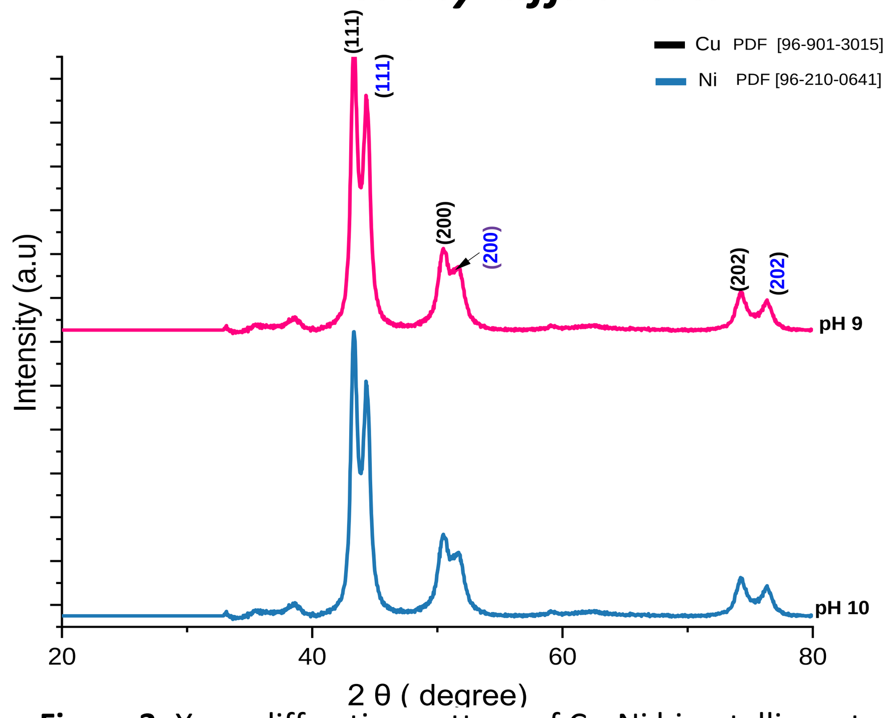


Figure 3. X-ray diffraction pattern of Cu-Ni bimetallic material.

FTIR

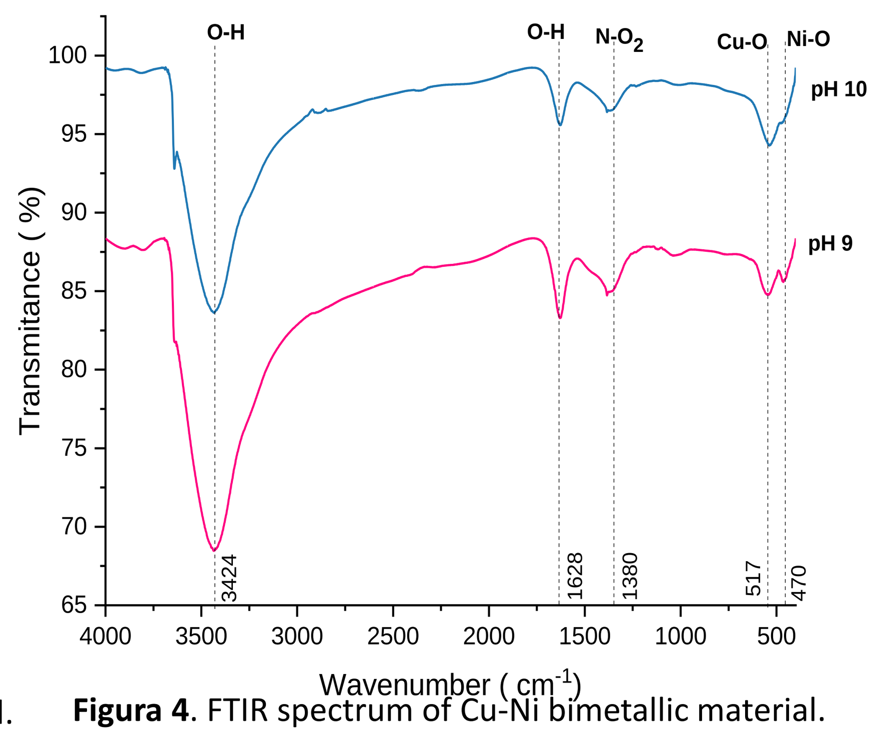
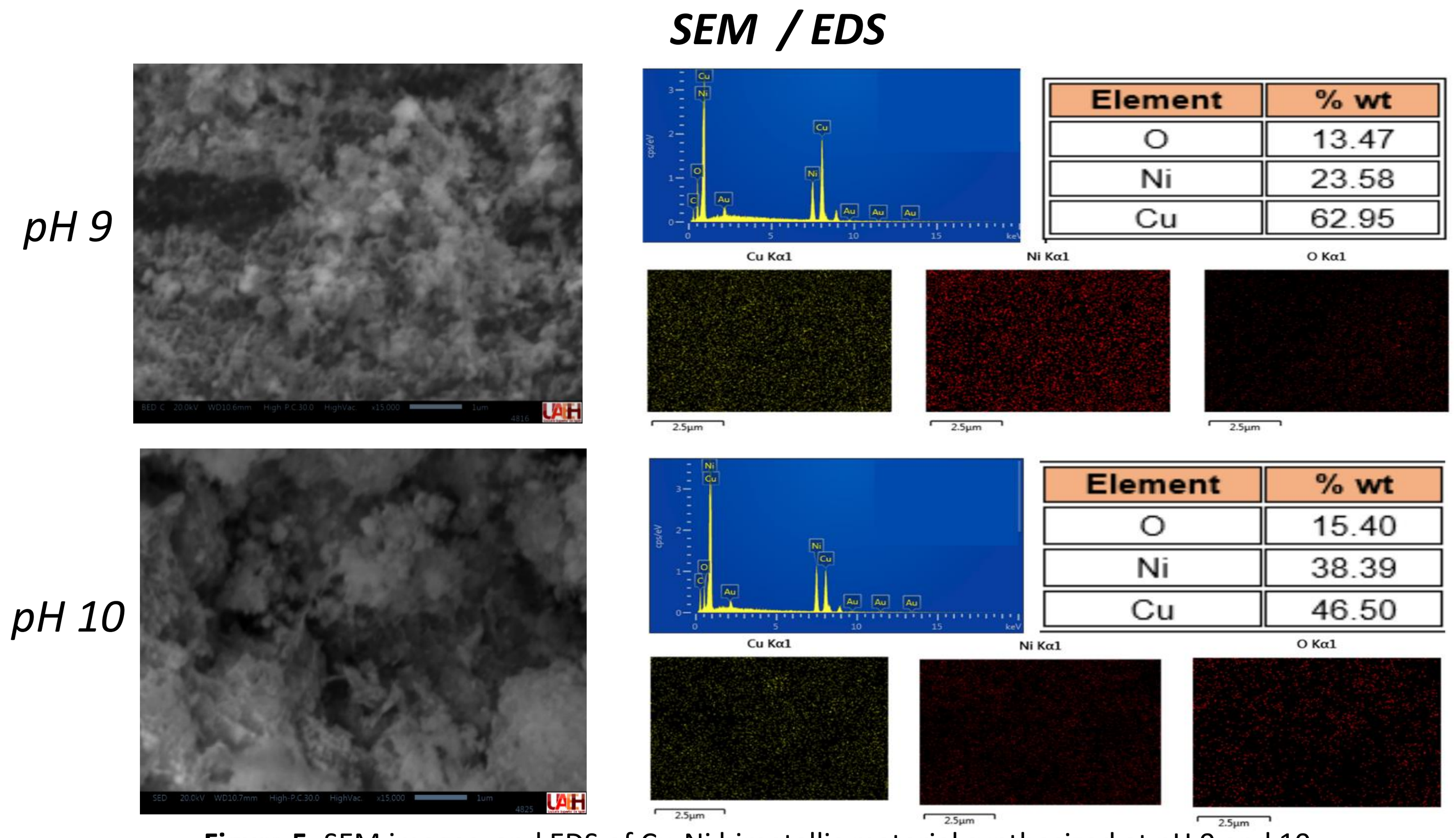


Figura 4. FTIR spectrum of Cu-Ni bimetallic material.

Table 1. Rietveld refinement parameters obtained from the XRD patterns.

pH	Phase	Cristallite size (nm)	Microstrain (adim)	Cell parameters (Å) a	Goodness-of fit	
					χ^2	Rwp
9	Cu	20.544 ± 0.440	$3.182\times10^{-3} \pm 1.062\times10^{-4}$	3.623 ± 0.002	2.0	7.87
	Ni	16.519 ± 0.356	$3.495\times10^{-3} \pm 1.551\times10^{-4}$	3.546 ± 0.002		
10	Cu	21.469 ± 4.054	$2.290\times10^{-3} \pm 1.324\times10^{-4}$	3.604 ± 0.0004	1.8	7.21
	Ni	16.65 ± 0.2151	$2.064\times10^{-4} \pm 4.227\times10^{-5}$	3.527 ± 0.0005		

SEM / EDS



pH 9

Element	% wt
O	13.47
Ni	23.58
Cu	62.95

pH 10

Element	% wt
O	15.40
Ni	38.39
Cu	46.50

Figura 5. SEM images and EDS of Cu-Ni bimetallic material synthesized at pH 9 and 10.

CONCLUSION

Characterization techniques confirmed the formation of a Cu-Ni bimetallic system. X-ray diffraction was used to identify the phases corresponding to both metals, and Rietveld refinement was performed to obtain detailed information on the crystal structure. FTIR spectroscopy was used to identify the functional groups present, while SEM images allowed observation of the morphology of the material, revealing the presence of bars and spheres. In addition, EDS confirmed the elemental composition of the system, verifying the presence of copper and nickel. It was confirmed that the bimetallic material is obtained in conditions of pH 9 and 10, however, the material obtained at pH 9 shows less crystallite size and more stable morphology.

FUTURE WORK / REFERENCES

The material obtained will be evaluated as a receptor element in capacitive biosensors, assessing its behavior and response to glucose detection.

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