

## **MARIANNY Y. COMBARIZA, PhD**

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Professor of Chemistry, Senior Researcher

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### **PROFESSIONAL SUMMARY**

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Marianny Y. Combariza is a senior scientist with a strong trajectory in instrumental chemical analysis, biomaterials, and the development of sustainable materials. Her scientific work focuses on designing and applying chemical technologies to understand, mitigate, and transform environmental issues by integrating advanced analytical chemistry, materials science, and the principles of the circular bioeconomy. She is committed to improving material circularity through the development of sustainable technologies and promoting science-based decision-making for the agroindustrial and technological sectors of Colombia.

Her research specializes in nanotechnology applied to biomass, specifically the isolation, characterization, modification, and technological uses of primary metabolites in biomass: cellulose, lignin, and hemicellulose. Her scientific work in cellulose and nanocellulose, extracted from lignocellulosic residues, such as cacao, fique, and palm oil, forms the basis for creating functional materials, including additives for emulsion breaking and stabilization, nanocomposites for highly efficient removal of recalcitrant water contaminants, and functional materials for nutrient capture and release from wastewater. She also leads biotechnological efforts to valorize sugar-rich agroindustrial residues for the production of biopolymers, such as polyhydroxyalkanoates (PHAs) and biocellulose. These lines of research support a model of material circularity by driving solutions to reduce reliance on synthetic polymers and mitigate environmental contamination.

### **AREAS OF SPECIALTY**

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- Biomaterials and circular economy.
- Analytical chemistry and scientific instrumentation (High-Resolution Mass Spectrometry).
- Biopolymers (Cellulose, lignin, hemicellulose, PHA, and cellulose-based biocomposites).
- Leadership in research and innovation.
- Higher education and development of scientific capacities.

### **PROFESSIONAL EXPERIENCE**

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Professor of Chemistry / Senior Researcher in Chemistry; Universidad Industrial de Santander, Bucaramanga-Colombia | 2007 – present

- Leading research initiatives in biopolymers, sustainable materials, biomarker analysis in phytoplankton, and environmental chemistry.
- Research advisor to undergraduate and graduate students (BSc, MSc, and PhD) in Chemistry and Chemical Engineering, focusing on biomarker analysis, biopolymers, biotransformations, and biomass usage.

- Senior Researcher (Colombian Ministry of Science and Technology) in Analytical Chemistry (Biomarker analysis by mass spectrometry) and Biopolymers (Cellulose, lignin, hemicellulose, PHA, and cellulose-based biocomposites).

Director, Center for Environmental Research (CEIAM); Universidad Industrial de Santander, Bucaramanga-Colombia | 2007 – present

- Advises undergraduate and graduate students on research projects related to analytical environmental chemistry and the transformation of residual biomass from agro-industrial crops.
- Coordinates strategic initiatives in biomass transformation, circular economy, and pollution mitigation.
- Manages environmental analysis services (air, water, soil) for private industries (Biofuels, petroleum, food, recreation) and public organizations.

## EDUCATION

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- PhD Chemistry, University of Massachusetts-Amherst, USA, 2004
- MSc Analytical Chemistry, University of Massachusetts-Amherst, USA, 2003
- MSc Analytical Chemistry, Universidad Industrial de Santander, Bucaramanga, Colombia, 1996
- BSc Chemistry, Universidad Industrial de Santander, Bucaramanga, Colombia, 1994

## RESEARCH FOCUS AND OUTCOMES

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### 1. Nanocellulose and Cellulose-Based Functional Materials

#### *Research Focus*

Isolation, characterization, and modification of cellulose and nanocellulose extracted from lignocellulosic residues (cacao fruits, fique, palm oil) for environmental applications and advanced materials.

#### *Key Outcomes and Developments*

**Synthesis and Characterization:** Developed methods for the isolation and characterization of cellulose nanofibrils from Colombian fique decortication by-products and explored the composition of raw and delignified Colombian fique fibers, tow, and pulp. Also studied the influence of reaction variables on the surface chemistry of cellulose nanofibers derived from palm oil empty fruit bunches.

**Emulsion Management (Petroleum Industry):** Developed nanocellulose-based materials to address petroleum challenges, including amidated cellulose nanofibrils as demulsifying agents for water-in-heavy-crude-oil emulsion and demonstrated nanocellulose as an inhibitor of water-in-crude oil emulsion formation. Also developed a hydrophobic cellulosic membrane for separating asphaltene-stabilized water from oil in emulsions.

Contaminant Remediation: Created nanocomposites for water treatment, such as a green cellulose based Fe<sub>3</sub>O<sub>4</sub> bionanocomposite used for textile wastewater depuration. Also led the synthesis of a biocomposite of nanostructured MnO<sub>2</sub> and Fique fibers for efficient textile dye degradation.

## 2. Valorization of Agroindustrial Residues (Biomass Characterization and Bioproducts)

### *Research Focus*

Transforming agroindustrial waste (cacao, palm, coffee, glycerol) into high-value bioproducts, including biopolymers (PHAs and biocellulose) and specialty chemicals.

### *Key Outcomes and Developments*

Cacao Residue Transformation: Conducted mass balance and compositional analysis of biomass outputs from cacao fruits. Developed processes for cellulose biosynthesis using simple sugars available in residual cacao mucilage exudate, and produced polyhydroxyalkanoates (PHAs) from cacao fruit liquid residues using a wild-type *Bacillus megaterium* strain. Also created modified biogenic nanocellulose and PHB from cacao fruit waste additives for enhanced mechanical and barrier performance of PHBV films.

Biopolymer Production: Polyhydroxybutyrate (PHB) biosynthesis from raw glycerol obtained from biodiesel residues using a wild-type *Bacillus Megaterium* strain. Enhancement of PHA production by a mixed microbial culture using VFA derived from yeast industry wastewater fermentation.

## 3. Selected Patents

*Innovations in materials derived from biomass for environmental applications:*

- Compositions of oxidized or sulfonated nanocellulose to inhibit the formation of emulsions (Patent NC2016/0005653).
- Nanofluid for the breaking of water in heavy crude emulsions that comprises amidated cellulose nanofibers (Patent NC2016/0002323).
- Process for elaborating modified bacterial cellulose with triglycerides (Patent NC2018/0014024).
- Process to degrade or remove contaminants from aqueous matrices (Patent NC2016/0006149).
- Material useful in the removal of contaminants in liquid matrices (Pub. No.:WO/2014/033642 A2; USA-20150315048).

## 4. Biomass-related selected publications (Last five years)

- Ramírez-Tarazona, Y.; Calderón-Vergara, L.A.; Blanco-Tirado, C.; **Combariza, M.Y.** Ammonium “catch and release” from wastewater using TEMPO-oxidized cellulose nanofiber beads. *RSC Advances*, **2025**, Submitted.

- Martínez-Ramírez, A.P.; Mantilla, N.; Ramírez-Contreras, N.; Blanco-Tirado, C.; García-Núñez, J.A.; **Combariza, M.Y.** Tissue Type, Cultivar, and Pretreatment Effects on the Biomass Chemistry of Oil Palm Empty Fruit Bunch toward Circular Bioeconomy Applications. *Cellulose*, **2025**, Submitted.
- Gamboa-Suárez, M.A.; Posada Rubiano, N.C.; Suárez-Rodríguez, S.J.; Blanco-Tirado, C.; Sierra, C.A.; Quintero-Silva, M.J.; **Combariza, M.Y.** Modified biogenic nanocellulose and PHB from cacao fruit waste for enhanced mechanical and barrier performance of PHBV films. *Carbohydrate Polymer Technologies and Applications*, **2025**, *12*, 101010.
- Cifuentes, M.C.; Amaya, D.A.; Blanco-Tirado, C.; **Combariza, M.Y.** “Exploring the dual role of TEMPO-oxidized cellulose nanofibers in CdSe quantum dot synthesis for biocomposites in metal ion chemosensing”, *Materials Advances*, **2025**, *6*(21), 7919-7931.
- Quintero-Silva, M.J., Suarez-Rodríguez, S.J., Gamboa-Suárez, M.A.; Blanco-Tirado, C.; **Combariza, M.Y.** Polyhydroxyalkanoates Production from Cacao Fruit Liquid Residues Using a Wild *Bacillus megaterium* Strain: Preliminary Study. *J Polym Environ.* **2024**, *32*, 1289-1303.
- Martínez-Ramírez, A.P.; Rincón-Ortiz, S.A.; Baldovino-Medrano, V.G.; Blanco-Tirado, C.; **Combariza, M.Y.** Influence of reaction variables on the surface chemistry of cellulose nanofibers derived from palm oil empty fruit bunches. *RSC Advances*, **2023**, *13*, 36117-36129.
- Aldana, M.Y.; Bustos, Y.; Espinoza, L.A.; Ramírez, A.; Nabarlatz, D.A.; Blanco-Tirado, C.; **Combariza, M.Y.** Influence of temperature and pH during cacao mucilage exudate concentration on cacao syrup composition. *International Journal of Food Science and Technology*, **2023**, *58*(12), 6817-6824.
- Oñate-Gutiérrez, J.A.; Díaz-Sánchez, L.M.; Urbina, D.L.; Pinzón, J.R.; Blanco-Tirado, C.; **Combariza, M.Y.** Exploring the chemical composition and coloring qualities of cacao fruit epicarp extracts. *RSC Advances*, **2023**, *13*(19), 12712.
- Ravelo-Nieto, E.; Ovalle-Serrano, S.A.; Gutiérrez-Pineda, E.A.; Blanco-Tirado, C.; **Combariza, M.Y.** Textile wastewater depuration using a green cellulose based Fe<sub>3</sub>O<sub>4</sub> bionanocomposite. *Journal of Environmental Chemical Engineering* **2023**, *11*(2), 109516.
- Vergara-Mendoza, M.; Martínez, G.R.; Blanco-Tirado, C.; Combariza, M.Y. Mass Balance and Compositional Analysis of Biomass Outputs from Cacao Fruits. *Molecules*, **2022**, *27*, 3717.
- Martínez-Ramírez, A.P.; Blanco-Tirado, C.; Combariza, M.Y. Perspectives in Nanocellulose for Crude Oil Recovery: A Minireview. *Energy&Fuels*, **2021**, *35*, 15381-15397.
- Saavedra-Sanabria, O.L.; Durán, D.; Cabezas, J.; Hernández, I.; Blanco-Tirado, C.; Combariza, M.Y. Cellulose biosynthesis using simple sugars available in residual cacao mucilage exudate. *Carbohydrate polymers*, **2021**, *274*, 118645.

## 5. Selected plenary lectures & conference highlights

- Enverdeciendo el futuro de Colombia: Oportunidades en el uso de biomasa residual agroindustrial en energía, combustibles y materiales (ACS Science Talks, June, 2024).
- Cacao Fruit's Metamorphosis: From Byproducts to Bioproducts (Programa de Plásticos Circulares en las Américas -CPAP, October, 2023).

- Biomasa y bioeconomía ¿Dónde está la industria de palma? (XX Conferencia Internacional de Palma de Aceite, September, 2022).
- Sensing and surface-active materials based on nanocellulose (VI Jornada de Pós-graduação e Pesquisa em Química, Rio de Janeiro, Brazil, November 2022).
- Materiales funcionales basados en celulosa (Colombianas haciendo Ciencia, Virtual, July, 2020).
- Functional cellulose nanocrystals and nanofibers obtained by acid hydrolysis of Colombian Fique fibers (American Chemical Society SPRING 2019 National Meeting & Exposition, Orlando, USA, March 2019).

## **MENTORSHIP AND ADVISING**

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Principal advisor for 23 defended Ph.D. theses and/or master's dissertations as the principal advisor (as of 2025).

Advising focused on: Biopolymers, biotransformations, biomass usage, biocomposites, and sustainable materials.

Ph.D. graduates include specialization in: Advanced materials from fique fibers nanocellulose, functional materials from palm oil residual biomass, and PHB production using biodiesel residual glycerol.

Master's graduates include specialization in: Nanocellulosic functionalized materials for destabilizing water-in-oil emulsions, bacterial cellulose production from residual liquid effluents from coffee fermentation, and biocomposite synthesis from fique bagasse/tow cellulose microfibrils.

## **RESEARCH FUNDING**

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Professor Combariza has received over 3.0 MM USD in funding (from the Colombian Royalty System, the Ministry of Science, Technology, and Innovation, and international funding agencies) for her research to understand and explore new uses for residual lignocellulosic materials in Colombia.