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Opinion

SICOAQ 2024: Launching the First Colombian Astrochemistry Symposium in Bogotá

SICOAQ 2024: Lanzamiento del Primer Simposio Colombiano de Astroquímica en Bogotá

Abstract

The First Colombian Astrochemistry Symposium (SICOAQ), held in Bogotá in October 2024, brought together 98 participants, including 23 speakers, to foster interdisciplinary collaboration in the rapidly growing field of astrochemistry. The programme featured engaging lectures, courses, and discussions on a wide variety of topics, extending from chemical processes in planet-forming discs and the astrochemical conditions influencing planetary habitability to the complex astrochemistry of the interstellar medium in distant galaxies. The symposium underscored the importance of gender equality in Science, Technology, Engineering, and Mathematics (STEM), providing a platform for empowering women in science. It facilitated national and international collaboration, strengthening scientific networks, and advancing astrochemistry research and education across Latin America. Following its success, the second edition is planned for 2027 at the University of Valle in Cali, Colombia, where efforts to promote astrochemistry through education and research will be extended further.

Keywords: Astrochemistry; Astrobiology; Space science; Research collaboration; Science outreach; Gender equality.

Resumen

El Primer Simposio Colombiano de Astroquímica (SICOAQ), celebrado en Bogotá en octubre de 2024, reunió a 98 participantes, incluidos 23 ponentes, con el objetivo de fomentar la colaboración interdisciplinaria en astroquímica, un campo en rápido crecimiento. El programa incluyó conferencias, cursos y discusiones sobre una amplia variedad de temas: desde los procesos químicos en discos formadores de planetas y las condiciones astroquímicas que influyen en la habitabilidad planetaria, hasta la compleja astroquímica del medio interestelar en galaxias distantes. El simposio destacó la importancia de la igualdad de género en las disciplinas de ciencia, tecnología, ingeniería y matemáticas (CTIM) para brindar una plataforma de empoderamiento a las mujeres en la ciencia. Además, facilitó la colaboración nacional e internacional, fortaleciendo redes científicas y promoviendo la investigación y la educación en astroquímica en toda América Latina. Tras su éxito, se planea una segunda edición en 2027 en la Universidad del Valle en Cali, Colombia, que ampliará los esfuerzos para promover la astroquímica a través de la educación y la investigación.

Palabras clave: Astroquímica; Astrobiología; Ciencias espaciales; Colaboración científica; Divulgación científica; Igualdad de género.

Introduction

Astrochemistry is an interdisciplinary field dedicated to the study of chemical processes occurring in cosmic environments (**Tielens**, 2013). It primarily focuses on the transformation of matter in regions subject to extreme conditions such as intense radiation, very low temperatures, and high-vacuum settings that differ markedly from terrestrial environments. These processes are not only fundamental to understanding the chemical complexity of the interstellar medium (ISM) but are also crucial for tracing the origins of molecules that play a role in biological processes that define life as we know it. Furthermore, astrochemistry

establishes vital links between the ISM and planetary science, particularly in understanding how chemical processes influence the formation and composition of planetary systems, including the Solar System.

Despite its importance, the field faces significant challenges, especially in obtaining high-resolution data due to the vast distances involved and the inherent limitations of observational tools. Simulating these extreme conditions in controlled laboratory settings is both complex and resource-intensive, further complicating efforts to fully unravel the intricate processes at stake. This necessitates an integrated approach, combining astronomical observations, theoretical modelling, and laboratory experiments. This synergy is particularly vital as advancements in receivers and instrumentation for radio and space telescopes, such as the Yebes 40m in Spain, the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile, and the James Webb Space Telescope (JWST), continue to enable the detection of new molecular species.

These new observatories have greatly improved the frequency and precision of observations of distant chemical environments, enhancing our understanding of the chemical complexity and molecular nature of the Universe. Studies have revealed the ubiquity of complex organic molecules (COMs), including alcohols, ketones, amines, nitriles, and polycyclic aromatic hydrocarbons (PAHs), alongside various organic and inorganic compounds, such as prebiotic molecules, throughout space. In the ISM alone, over 320 molecules have been identified to date (https://cdms.astro.uni-koeln.de/classic/molecules), with an even greater variety of compounds including amino acids exhibiting unexpected enantiomeric excess detected in meteorites (**Cronin and Pizzarello**, 1997). Molecular formation arises from unique processes driven by cosmic radiation, magnetic fields, and interactions with charged particles occurring both in the gas phase and through catalytic processes on the surfaces of interstellar ices, which form as molecules freeze onto interstellar grains (**Cuppen *et al.***, 2024). Investigating these chemical pathways not only deepens our knowledge of matter in conditions beyond terrestrial norms but also offers the opportunity to trace the physico-chemical conditions of diverse astronomical environments. Ultimately, this research sheds light on our chemical origins, contributing to a broader understanding of the Universe and our place within it.

This exploration has far-reaching implications beyond academic interest. It contributes directly to the development of advanced instrumentation and laboratory technology, refined analytical techniques, and more powerful computational methods. Such improvements subsequently foster progress in materials science and engineering, with tangible applications in areas as diverse as manufacturing processes and environmental monitoring. Crucially, this exploration addresses foundational philosophical questions that have long driven humanity: What are the chemical origins of life? Is there life beyond Earth? Additionally, it encourages a responsible approach to the sustainable utilisation of space by highlighting the importance of designing durable and efficient, but also environmentally friendly materials for space exploration alongside advancing technologies like space agriculture that are critical for supporting long-term human presence beyond Earth.

Pursuing these efforts should not be confined to a select group of economically privileged nations. To ensure that their technical and intellectual benefit are distributed fairly, and to maintain momentum in uncovering the Universe's underlying chemical principles, it is essential to broaden participation and capacity-building initiatives (**Helou *et al.***, 2024). In particular, expanding opportunities for countries in the Global South strengthens the collective capabilities of humankind. Such inclusive engagement ensures that the ongoing quest to understand the chemical evolution of the Universe and the broader technological and philosophical gains that follow are shared equitably by all.

With these motivations in mind, a group of Colombian scientists, both within the country and abroad, organised the First Colombian Astrochemistry Symposium (SICOAQ) in October 2024 (**Figure 1**). This event aimed to galvanise collaboration and knowledge exchange, thereby strengthening the community of researchers dedicated to understanding the chemical complexities of the Universe.

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Figure 1. SICOAQ logo and official photograph taken in front of the Observatorio Astronómico Nacional de Colombia at Universidad Nacional de Colombia in Bogotá

The Symposium

Research themes and organising committee

SICOAQ (https://sicoaq.com/), held in Bogotá, Colombia, represented a key milestone for astrochemistry in Colombia and Latin America, bringing together an interdisciplinary community spanning astronomy, chemistry, physics, and biology. Topics ranged from the chemistry and physics of planet-forming discs (**Booth *et al.***, 2021; **Ramírez-Tannus *et al.***, 2023; **van der Marel *et al.***, 2013), solar-type protostars (**Quitián-Lara *et al.***, 2023), and planetary nebulae (**Akras *et al.***, 2024), to advanced theoretical approaches in astrochemistry (**Oliveira *et al.***, 2023; **Puzzarini and Barone**, 2020; **Tsuge *et al.***, 2023). Other discussions included laboratory investigations of interstellar ice chemistry (**Kruczkiewicz *et al.***, 2024) and insights into the role of PAH emission in star formation and black hole growth (**Martins-Franco and Menéndez-Delmestre**, 2021; **Santos *et al.***, 2022). The symposium also explored the interplay between astrochemistry and galactic dynamics (**Mendoza *et al.***, 2021) and the influence of metal mixing on star-forming galaxies (**Abril-Melgarejo *et al.***, 2024). Attendees presented geochemical perspectives and their connections to astrobiology and habitability (**Abrevaya *et al.***, 2024; **Cadena *et al.***, 2024; **Méndez *et al.***, 2021), highlighting the synergy between planetary science and the origins of life. The event underscored Latin America's growing leadership in astrochemistry, with significant educational, outreach, and astrobiological efforts.

SICOAQ was designed to bring together scientists, academics, and students interested in the topics of astrochemistry, astrobiology, and planetary science (**Figure 2**). A total of 23 specialised talks were held, including three keynote lectures and 20 plenary sessions (see **Table 1** and below for further statistics). The symposium was inaugurated by Prof Mario-Armando Higuera-G, Director of the National Astronomical Observatory of Colombia (Observatorio Astronómico Nacional, OAN) and President of the Colombian Community of Astronomers, Astrophysicists, and Cosmologists (Comunidad de Astrónomos, Astrofísicos y Cosmólogos de Colombia, AstroCO) (https://astroco.org/), alongside

Figure 2. SICOAQ Scientific and Local Committee Members. From left to right: Felipe Fantuzzi, Mario-Armando Higuera-G, Alejandro Guerrero-Caicedo, Eva Méndez-Robayo, Sergio A. Cifuentes-Vásquez, Heidy M. Quitián-Lara, Karín Menéndez-Delmestre, and M. Alejandra Lemus-Nemocón

Cristian Goez Theran from the Aerospace Management Team of the Ministry of Science, Technology, and Innovation of Colombia. The first keynote lecture was given by Prof Nigel J. Mason, Coordinator of Europlanet 2024 Research Infrastructure and former president of the Europlanet Society (**Mason**, 2009) (https://www.europlanet-society.org/). Prof Mason emphasised the unique opportunity that events like SICOAQ offer for fostering new and fruitful scientific collaborations. He underscored the importance of integrating Colombia into the European research landscape, not only by granting Colombian researchers access to European infrastructure but also by developing local capacities in Colombia that could attract the European scientific community to the country. Among the invited speakers were renowned, leading figures such as Prof José Cernicharo, principal investigator of the QUIJOTE project (**Cernicharo *et al.***, 2022), one of the most successful programmes in astrochemistry for identifying molecules in space.

Structure, statistics, and participants

The symposium featured a comprehensive three-day schedule of lectures and courses complemented by a fourth day dedicated to cultural activities, along with an outreach BootCamp held as a pre-event. During this time, scientists from universities and research centres in Colombia, Spain, UK, Germany, Netherlands, Italy, Brazil, Argentina, México, and USA presented their research both in person and remotely (**Table 1**). Students attended in person from universities in Colombia, Mexico, Brazil, Chile, UK, and Germany, while remote participants joined from Colombia, Guatemala, Chile, Brazil, Spain, and Germany.

The second day of the symposium featured four intensive four-hour courses focused on distinctive modern themes in astrochemistry research, with each course accommodating approximately 15 participants, primarily undergraduate students. These courses provided attendees with the opportunity to engage directly with leading scientists in the four main areas of astrochemistry. The topics included Experimental Astrochemistry, delivered by Prof Cernicharo; Observational Astrochemistry, presented by Dr Marcelino Agúndez, and Theory and Simulations, taught by Dr Germán Molpeceres—all from the Spanish National Research Council (CSIC). Additionally, the course on Astrochemistry Outreach and Education was led by Dr Miguel A. Sabadell from Fundación Albireo Cultura Científica, Spain. To ensure accessibility, all courses were conducted in Spanish, while both Spanish and English served as the official languages of the symposium.

Table 1. List of invited keynote and plenary in-person and online speakers and their affiliations

Speaker	Affiliation
Albeiro Restrepo	University of Antioquia, Colombia
Alejandro Guerrero-Caicedo	University of Valle & amp; Free University, Colombia
Alice Booth	Center for Astrophysics, Harvard & Smithsonian, USA
Cristina Puzzarini	University of Bologna, Italy
Edgar Mendoza	University of Huelva, Spain
Felipe Fantuzzi	University of Kent, UK
Franciele Kruczkiewicz	Leiden Observatory, Netherlands
Germán Molpeceres	Spanish National Research Council (CSIC), Spain
Heidy M. Quitián-Lara	Max Planck Institute for Extraterrestrial Physics, Germany
Isabel Aleman	University of São Paulo, Brazil
Jesús Martínez-Frías	Spanish National Research Council (CSIC), Spain
José Cernicharo	Spanish National Research Council (CSIC), Spain
Karín Menéndez-Delmestre	Federal University of Rio de Janeiro, Brazil
Marcelino Agúndez	Spanish National Research Council (CSIC), Spain
María Claudia Ramírez-Tannus	Max Planck Institute for Astronomy, Germany
Mario-Armando Higuera-G	National Astronomical Observatory, Colombia
Miguel A. Sabadell	Fundación Albireo Cultura Científica, Spain
Nienke van der Marel	Leiden Observatory, Netherlands
Nigel J. Mason	University of Kent, UK
Paola Pinilla	University College London, UK
Sandra I. Ramírez	Autonomous University of the State of Morelos, Mexico
Valentina Abril Melgarejo	Space Telescope Science Institute, USA
Ximena C. Abrevaya	Institute of Astronomy and Space Physics, Argentina

In total, SICOAQ hosted 98 participants, including 23 speakers (**Figure 3**). The remaining 75 attendees included 45 undergraduate students, 11 MSc students, seven PhD students, six postdoctoral research associates (PDRAs), and six professionals dedicated to teaching science and astronomy at Colombian institutions.

In terms of gender representation, SICOAQ featured 48 female participants, representing 49.0% of the total attendees (**Figure 3**). Among students, women constituted 49.2% (31 out of 63), forming a majority at the postgraduate level (61.1%, 11 out of 18). Women also held the majority among PDRAs (83.3%, 5 out of 6) and speakers (52.2%, 12 out of 23). This balanced representation highlights the symposium's strong commitment to promoting inclusivity and diversity within the scientific community.

To enhance the visibility of the conference, the programme included flash talks by 31 students and academics who also contributed with posters. These participants represented a variety of institutions, 19 from Colombia and 12 from abroad. Among the poster presenters and flash talk participants, there was a near gender parity, with 16 women and 15 men.

All poster submissions were considered for a best-poster competition using the following criteria: the quality of the flash talk, the organisation of the poster content, the relevance and depth of the information presented, and the clarity of the accompanying graphs. A panel of evaluators, comprising members of the scientific committee and invited professors, selected two outstanding works based on these criteria. The winners not only received an award certificate but were allowed to deliver an extended presentation of their research, further showcasing their contributions to the symposium. The awardees were

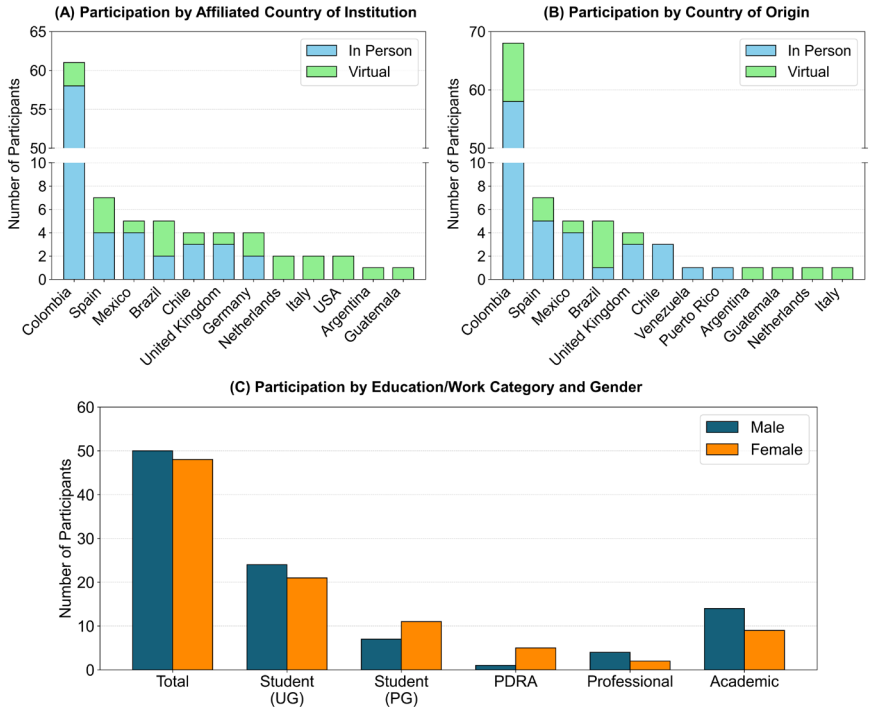

Figure 3. General statistics of SICOAQ: **(A)** Distribution of participants by the country of their affiliated institution, with light blue indicating in-person attendees and light green representing virtual attendees. **(B)** Distribution of participants by nationality, following the same colour scheme. **(C)** Participants categorised by education or professional level and broken down by gender, with blue representing male participants and orange indicating female participants. UG: undergraduate; PG: postgraduate

Lisset Noriega from CINVESTAV-Mérida, Mexico, who presented *C_2H_7NO Isomers in Interstellar Space: A Quantum Theoretical Study*, and Eva Méndez-Robayo from the Observatorio Astronómico Nacional, Colombia, who secured first place overall with her work entitled *Chemical Modeling of Methanol as an Extragalactic Shock Tracer* (**Méndez-Robayo**, 2024).

Driven by a desire to promote discussions regarding inclusion and diversity, SICOAQ dedicated the final day of the event to discussions on women's empowerment in STEM fields. Topics included the challenges of female participation in Latin American science and the involvement of women in astronomy and scientific careers in disciplines such as chemistry and physics. This session highlighted the symposium's commitment to fostering diversity and addressing gender disparities within the scientific community.

Outreach and cultural activities

On the day preceding the official start of the conference, a specialised workshop on planetary formation and stellar evolution was conducted, targeting public school teachers from various regions of Colombia, including Cundinamarca, Antioquia, Santander, and Magdalena. Approximately 50 educators participated in this BootCamp, which was led by Dr. Heidy M. Quitián-Lara, Dr. Miguel A. Sabadell, and Dr. Alejandro Guerrero-Caicedo. The workshop aimed to equip teachers with the knowledge and tools to effectively convey the wonders of astrochemistry and astrobiology, fostering curiosity and cultivating scientific understanding among the next generation of students.

Last but not least, SICOAQ included a guided tour of the historic National Astronomical Observatory of Colombia, the oldest observatory in the Americas. Visitors learned about key figures in Colombian science, including José Celestino Mutis, who spearheaded the

observatory's foundation, and Francisco José de Caldas, its first director and a pioneer in astronomy and geography, tragically executed during the Spanish reconquest of New Granada. The tour also emphasised the observatory's critical role in Colombia's independence, serving as a hub for scientific advancement and revolutionary thought during the early 19th century. It also highlighted the legacy of Julio Garavito, a renowned Colombian astronomer whose contributions to celestial mechanics earned him international recognition, further showcasing the observatory's lasting impact on the nation's scientific and historical heritage.

In addition to exploring the observatory's legacies, participants visited iconic museums in Bogotá, such as the Botero Museum and the Gold Museum, offering a glimpse into Colombia's vibrant cultural heritage. These experiences, combined with opportunities to enjoy Colombian gastronomy, allowed international visitors to immerse themselves in the country's history and culture, making their visit to Colombia an unforgettable experience.

Legacy of the meeting

SICOAQ has initiated new efforts to broaden the scope and impact of astrochemistry research across Latin America. Plans are in progress to establish a Latin American Network for Astrochemistry, Astrobiology, and Space Sciences (LANAS), bringing together Colombian organisations such as the Instituto de Astrobiología de Colombia and AstroCO, alongside regional collaborators including the Red Boliviana de Ciencias Planetarias y Exploración Espacial (https://www.redboliviana.org/), Agencia Espacial del Perú (CONIDA), Red Latinoamericana de Astrobiología (https://www.astrobiologialatam.org/), Sociedade Brasileira de Astrobiologia (https://sbastrobio.org/), and Sociedad Mexicana de Astrobiología A.C. (https://sites.google.com/soma.org.mx/soma-a-c). This network seeks to consolidate regional efforts, promote interdisciplinary collaboration, and drive innovation.

A notable development from the symposium is the creation of the "EuroCol Julio Garavito Astronomy Award", which will honour exceptional contributions to astronomy and astrochemistry by early-career researchers in Colombia. Early-career researchers include undergraduate and postgraduate students, postdoctoral fellows, and academics in the initial stages of their careers. The award includes a certificate, a feature on official platforms such as Europlanet, the University of Kent, and the Max Planck Institute, and a monetary prize. This initiative aims to celebrate significant achievements and support emerging talent by recognising milestones such as high-impact publications, exemplary PhD defences, innovative research methods, contributions to international collaborations, and impactful teaching and outreach activities that inspire the next generation of scientists.

SICOAQ also advanced discussions for Colombia's membership in Europlanet AISBL (*Association Internationale Sans But Lucratif*). Membership will connect Colombian researchers with an international community of planetary scientists, offering access to advanced facilities, mentoring initiatives, and funding programmes. Such an affiliation will enhance resources for Colombian researchers, strengthening their contributions to planetary science and raising the country's global scientific standing.

The symposium's legacy lies in its efforts to enhance collaboration, advocate for diversity, and provide avenues for research and education. These initiatives have positioned SICOAQ as a catalyst for progress in astrochemistry across Latin America. With its first edition laying a strong foundation, plans are already in place for the next meeting in 2027 at the University of Valle in Cali. This venue was selected for its leadership in astrochemistry education, being the first in Colombia to offer an undergraduate course in the field. This upcoming edition promises to continue the momentum, further establishing SICOAQ as a cornerstone event for advancing astrochemistry in the region.

Conclusions

In summary, SICOAQ provided a comprehensive overview of the latest advances in astrochemistry across experimental, theoretical, observational, and outreach areas, while fostering integration, leadership, and collaboration at both national and international

levels. Attendees received advanced training in various fields, reinforcing Colombia's commitment to basic sciences and interdisciplinary research as the country positions itself as a key player in astrochemical studies. Recognising the community's strong interest, the scientific committee proposed making SICOAQ a regular event, with the second edition planned for 2027 at the University of Valle in Cali, Colombia. This symposium not only creates invaluable opportunities for scientific integration and collaboration between global institutions but also aims to engage more students through high-quality events, foster the identification of research niches, and promote the teaching of astrochemistry through outreach and educational courses, thus contributing to the growth of the discipline in Latin America.

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Author contributions

HMQL coordinated the overall work and provided project oversight. EMR, MALN, and SACV conducted the statistical analyses under the guidance of HMQL and FF. HMQL and FF jointly prepared the initial manuscript draft. All authors contributed to the review and editing of the manuscript and approved its final version for publication.

Conflicts of interest

The authors declare no conflicts of interest.

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