



# revista facultad de ingeniería

Universidad de Antioquia
June, 2018

No. **87**ISSN 0120-6230

e-ISSN 2422-2844



### Revista Facultad de Ingeniería, Universidad de Antioquia, No. 87, pp. 3, 2018

No. 87 June, 2018 ISSN 0120-6230 e-ISSN 2422-2844

Rector

John Jairo Arboleda Céspedes

Dean

Jesús Francisco Vargas Bonilla

Editor-in-Chief

Maryory Astrid Gómez Botero

Editorial Board

Luis Ribeiro Geosistemas Instituto Superior Técnico Lisboa, Portugal

Eduardo Miró

Instituto de Investigaciones en Catálisis y Petroquímica (INCAPE,

CONICET)

Santa Fe, Argentina

Octavio Armas Vergel

ETS Ingenieros Industriales Ciudad Real

Universidad de Castilla La Mancha, España

Jean Denis Taupin

HydroSciences, Institute de recherche pour le développement

Montpellier, Francia

Román Hermida Facultad de Informática Universidad Complutense

Madrid, España

Oscar Rosa Mattos

Departamento Engenharia Metalúrgica e de Materiais

Universidade Federal do Rio de Janeiro

Brasil

Carles Corbella Roca

Department of Mechanical & Aerospace Engineering

The George Washington University Washington, Estados Unidos

Ángel Pérez del Pino

Instituto de Ciencia de Materiales de Barcelona Consejo Superior de Investigaciones Científicas CSIC

Barcelona, España

Claudio Avignone Rossa

Faculty of Health and Medical Sciences

University of Surrey Guildford, Reino Unido

Jordi Morató Farreras

Coordinador Cátedra UNESCO de Sostenibilitat

Universitat Politècnica de Catalunya

España

Julián Andrés Rengifo Herrera

Centro de Investigación y Desarrollo en Ciencias Aplicadas

(CINDECA)

Buenos Aires, Argentina

Luis Armando Díaz Torres

Grupo de Espectroscopia de Materiales Avanzados y

Nanoestructurados (GEMANA) Centro de Investigaciones en Óptica

León, México

Lin, Hua-Tay

School of Electromechanical Engineering, Guangdong

University of Technology

Beijing, China

Kamal H. Khayat

Center for Infrastructure Engineering Studies

Missouri University of Science & Technology

Missouri, Estados Unidos

Waltraud M. Kriven

Department of Mechanical Science and Engineering

University of Illinois at Urbana-Champaign

Illinois, Estados Unidos

Juan Claudio Nino

Department of Materials Science and Engineering

University of Florida

Estados Únidos

João Paulo Davim

Department of Mechanical Engineering

University of Aveiro Aveiro, Portugal

Watson Vargas Escobar

Dpto. de Ingeniería Química

Universidad de los Andes, Colombia

Jorge Andrés Calderón Gutiérrez

Dpto. de Ingeniería de Materiales

Universidad de Antioquia, Colombia

Sebastián Isaza Ramírez

Dpto. Ingeniería Electrónica

Universidad de Antioquia, Colombia

Julián David Arias Londoño

Dpto. Ingeniería de Sistemas

Universidad de Antioquia, Colombia

Elena Valentina Gutiérrez Gutiérrez

Dpto. Ingeniería Industrial

Universidad de Antioquia, Colombia

Diana Catalina Rodríguez Loaiza

Escuela Ambiental

Universidad de Antioquia, Colombia

Scientific Board

Jesús Casanova Kindelan

Ingeniería Energética y Fluidomecánica

Universidad Politécnica de Madrid, España

Esteban Abad Holgado

Investigaciones Químicas y Ambientales, Consejo Superior de

Investigaciones Científicas

Barcelona, España

Georgina Fernández Villagómez

Ingeniería Química

Universidad Nacional Autónoma de México



### Revista Facultad de Ingeniería, Universidad de Antioquia, No. 87, pp. 4, 2018

Jiahua Jack Zhu
Department of Chemical and Biomolecular Engineering
University of Akron
United States

Vijay Gupta Mechanical and Aerospace Engineering Biomedical Engineering Materials Science and Engineering University of California, Los Angeles United States

At Urbana-Champaign, United States

Jean Paul Allain Radiation Surface Science and Engineering Lab (RSEEL) Department of Nuclear, Plasma, and Radiological Engineering University of Illinois

Dileep Singh Argonne National Laboratory Illinois, United States

Hernán E.M Carvajal Programa de Posgraduación en Geotecnia, Universidad de Brasilia Facultad de Minas, Universidad Nacional de Colombia

Néstor Jaime Aguirre Ramírez Escuela Ambiental Universidad de Antioquia, Colombia

Henry A. Colorado Sociedad Colombiana de Materiales y Minerales Ingeniería Mecánica Universidad de Antioquia, Colombia

Administrative Assistant Sandra Hernández Barrientos

### Proofreading

Jessica Tatiana Becerra Barco Leidy J. Hernández Zuluaga Juan Diego A. Prada Ramírez

### **English Proofreading** Claudia E. Urrego Zapata

### **Book Cover**

Image "Evaluation of the effect of the synthesis method on the performance of manganese spinel as cathode material in lithium-ion batteries" by Lina Maria Uribe-Grajales, Ferley Alejandro Vásquez-Arroyave, Jorge Enrique Thomas, Jorge Andrés Calderón-Gutiérrez.

### Lavout and printing

Revista Facultad de Ingeniería -redin- Universidad de Antioquia Extrategia Ecoprint publicidadextrategia@qmail.com

### Post

Reduced postal fare N° 842

### E-mail

revistaingenieria@udea.edu.co

### Web site

redin.udea.edu.co

The contents or any other legal restriction related to the articles is responsibility of the authors.

This issue was supported by Indexed Journals Fund of the VicePresident for Research, University of Antioquia Press

### Objective of Revista Facultad de Ingeniería

"The principal objective of the Revista Facultad de Ingeniería is to promote the publication of original and unpublished articles derived from experimental research, engineering simulations or review papers, developed by researchers and experts from national or international, public or private institutions."

# Table of contents

Editorial	7
Early fault detection in SiC-MOSFET with application in boost converter Leobardo Hernández-González, Climaco Arvizu-Ogilvie, Alejandro Tapia-Hernández, Mario Ponce-Silva, Abraham Claudio-Sánchez, Marco Rodríguez-Blanco, Jesús Aguayo-Alquicira	8
Latency analysis on W-band hybrid fiber-wireless link using software defined radio in real time Mónica Andrea Rico-Martínez , Álvaro Morales-Vicente, Rafael Puerta-Ramírez, Víctor Mehmeri-Dantas, Idelfonso Tafur-Monroy, Gloria Margarita Varón-Duran	16
Clay surface characteristics using atomic force microscopy Ricardo Andrés García-León, Eder Norberto Flórez-Solano, Carlos Humberto Acevedo-Peñaloza	23
Multi-objective optimization in biotechnological processes: application to plant cell suspension cultures of <i>Thevetia peruviana</i> Adriana Patricia Villegas-Quiceño, Juan Pablo Arias-Echeverri, Daira Aragón-Mena, Silvia Ochoa-Cáceres, Mario Evelio Arias-Zabala	35
Evaluation of the effect of the synthesis method on the performance of manganese spinel as cathode material in lithium-ion batteries Lina Maria Uribe-Grajales, Ferley Alejandro Vásquez-Arroyave, Jorge Enrique Thomas, Jorge Andrés Calderón-Gutiérrez	
Evaluation of stresses and deflections in expanded metal plates subjected to transverse loading José Ángel Matute-Peaspán, Gabriela Martínez-Bordes, Carlos Alberto Graciano-Gallego, Nelson Adolfo Loaiza-Ramoneses	50
Modeling and control of processes using the EMSO simulator and SIMATIC PLC as OPC interface Jonathan Ospino-Pinedo, Mauricio Esteban Sánchez, Luis Gerónimo Matallana-Pérez	58
Conceptual clustering: a new approach to student modeling in Intelligent Tutoring Systems Yunia Reyes-González, Natalia Martínez-Sánchez, Adolfo Díaz-Sardiñas, Marisol de la Caridad Patterson-Peña	70
Polyurethane flexible foam recycling via glycolysis using Zn/Sn/Al hydrotalcites as heterogeneous catalyst Yesica Dayana Morcillo-Bolaños, William José Malule-Herrera, Juan Carlos Ortiz-Arango, Aída Luz Villa-Holguín	77

# **EDITORIAL**

## **EXPOIngeniería 2018**

In 2018, the School of Engineering of the Universidad de Antioquia celebrates its first 75 years of existence, considered as a vibrant faculty, with historical origins and developments. In its beginnings, 1943, it took the name of School of Chemical Sciences and it was related to the School of Medicine; in 1944, the curriculum was modified and the name was changed to the School of Chemical Engineering. On December, 1957 it was transformed into the Faculty of Chemical Engineering.

Since its origins, there have been about fifteen thousand engineers trained in the School who have contributed to the development of the region and the country. Currently, the School of Engineering offers 18 undergraduate programs, the vast majority with high quality accreditation, 9 specializations, 9 master's degrees and 4 doctorate programs. Its commitment to high quality education remains firm to the more than 8,000 undergraduate students and nearly 1,000 graduate students.

With the natural evolution of the research, 40 research groups have been consolidated, and this Journal has become an important place for the dissemination of results of the various research projects developed, and over time it has attracted the attention of researchers from all Latin America.

The School of Engineering continues taking on new challenges that meet the needs of academic and scientific development of the communities and the productive sector at the national and regional level, and it also bets on the strengthening of University-Company-State relationships, the social projection and the internationalization. In this sense, and in alliance with the **Tecnnova** corporation, an entity with more than 10 years of experience in Science, Technology and Innovation, we propose the first edition of **EXPOingeniería 2018**, an event to collectively trace the future from development and sustainability in the region and the country from **October 16 to 19, 2018** in the Plaza Mayor Convention Center and in the Metropolitan Theater of Medellín.

**EXPOIngeniería 2018** will be the space for dialogue and the exchange of knowledge and challenges among three main actors

of society: industry, academia and the State. The fair will be the stage that will allow the acquired capacities through the time to be shown, and under a scheme that points to the development and sustainability, we will generate proposals that invite to the advance of the engineering and the society.

The academy will present the results and advances of the challenges addressed from the topics of the event with its business. and social impact, reinforcing the vocation for the **profession** among new students and reaffirming it among active professionals. In addition, the academic community can participate in the solution of innovation challenges posed by the industry. The State will expose the macro projects and the path traced to promote the growth and development of all macroeconomic indicators through sustainable investment policies in all areas of engineering. It will be able to participate in the operation of chaining/ business, this is the ideal time to reaffirm investor confidence in a country that is in the best stage of social, economic and cultural transition. The Industry will have the great opportunity to build high-level business allowing its products to be placed in the market and/or innovative services that present solutions to the visitors, buyers and other exhibitors; it can pose the challenges of innovation and participation in the chaining/ business operation-, additionally it can propose specialized lectures for its audiences. These presentations will allow the academy to know the priorities or real challenges that should be addressed in future research.

Additionally, this Journal joins the celebration by having a special edition of ExpoIngeniería2018; for submitting articles for this special issue, the Call for Papers included in this edition must be taken into account. The special issue will be published in 2019; for this publication, articles of high scientific quality will be considered, covering the main topics of ExpoIngeniería 2018 and V Workshop on Engineering Application-WEA 2018. The fields of knowledge within this edition are: Energy, Environment; Materials, Chemistry, Bioengineering, Infrastructure, Mobility, Logistics, Telecommunication, Information Technologies and Applied Computer Science in Engineering.

Jesús Francisco Vargas Bonilla Dean School of Engineering Universidad de Antioquia