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AYUDAS RAMÓN Y CAJAL
CONVOCATORIA 2014

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Título:

Integral multi-scale strategy for the optimal design and control of smart pilot bioprocessing plant towards the sustainable production of marine-based bioactive compounds from marine biomass

Resumen de la Memoria:

Current fishing practices result in the waste of several tonnes of valuable resources every year. However, from now on, vessels must unload both target and non-commercial species when arriving to land, as regulated by recent EU legislation. Therefore, an important quantity of low-value marine biomass has to be managed in an efficient manner to avoid its waste. Several added value bio-compounds apart from fishmeal and oil (like enzymes or nutraceuticals) can be obtained from the wide variety of discarded species trough different valorisation processes. Therefore, the aim of my research is the operational design and control of efficient bio-processes to be integrated in smart, self-controlling real pilot plants to upgrade by-catch, discards and wastes derived from fishing activity.

One of the strengths of this research line is the potential to share and transfer transversal methods, technologies and equipment$\diamond$s (from biochemical to control engineering) between the different bio-productions considered. Thereby, best available methods and technologies will be selected and optimized for valorizing fish by-products nowadays discarded. Scale up and efficient operation of the smart plants requires a precise quantitative description of material flows through the plant and in each unit or process. Mathematical models covering the relevant production scales (from plant inventories to process performance indicators, including also bioactivity and transport/delivery requirements) should be developed to that purpose. Because of the seasonality of the biomass supply and variability of product demand, the proposed plants will operate on a batch or semi-batch basis what calls for the solution of dynamic optimization problems to be solved as NLPs (nonlinear programming) for real-time optimization. Flexible operation of the multipurpose plant, which includes process stream integration and equipment scheduling, demands MINLP (mixed integer NLP) methods and algorithms to guide plant operation on a real-time basis, conditioned by the availability of raw material, expected product demand and product quality/bioactivity requirements. To that purpose, an optimized multi-layer (off-line and on-line) control methodology will be applied to all relevant phenomenological levels of the processes (from macro to micro/nano scale) in order to guarantee the required operation conditions.

Resumen del Currículum Vitae:

After completion of my BSc in Chemical Engineering at University of Santiago de Compostela (USC) in 2001, I began my PhD with an FPI grant of the MICINN in the Process Engineering Group (GEPRO) of the Marine Research Instituto (IIM $\diamond$ CSIC) in Vigo (Spain) under the supervision of Profs. Julio R. Banga and Antonio A. Alonso. My research during these years was focused on developing a set of conceptual and methodological tools based on thermodynamics that contributes to carrying out a systematic design of the control structure for a given process or chemical plant. Moreover, I also collaborated in the design, start-up, control and tuning of a multi-purpose valorisation pilot plant to transform fish by-products into added-value products. This time finished with the defense of my PhD Thesis in April 16th 2008 with the maximum qualification and the Doctorate Award given by University of Vigo.

During the second mid of 2008, I got a 3-years postdoctoral contract of the Program $\diamond$Ánxeles Alvariño$\diamond$ of Xunta de Galicia. This allowed me to continue my work as a postdoctoral researcher in the GEPRO Group (IIM-CSIC) due to my personal circumstances. In the period 2009-2012, my primary and basic research line was focused on the definition of optimal control profiles/policies to new scenarios/cases through the definition of a hierarchy multi-layer approach for optimal control of processes. Basically, it is constituted by an off-line level used to analyze different processing scenarios and an on-line or real-time optimization (RTO) level designed to react to possible disturbances and minimize the adverse effects over final products specifications based on the implemented precomputed policies obtained from the off-line layer. This methodology was successfully implemented on highly-used processes at real scale: the Open Plate Reactor and freeze-drying. My acquired background enable me to go and/or adapt myself into new research directions like the one of making the best use of the unwanted fish biomass (nowadays discarded) that, under the new regulations of the EC, has to be landed. In this framework, part of my research on the period 2010 until now was focused on: a) designing and tuning optimal fish biomass valorization prototypes/plants; b) creating an efficient and optimal network able to manage generated discards based on network theory and; c) applying classic stability and control theory to the fish stocks management and conservation policies.

I have published 22 papers in international scientific publications (5 more submitted or under preparation) with reviewing process and near 100 cites, being the first/second and/or corresponding author in all of them. Up to an 80% of all the publications are in scientific journals within 25% of highest impact factor of their topic area. I have participated and I participate in 9 different research projects (4 regional/national and 5 European), 2 as Technical Coordinator. In addition, I have presented 17 oral communications and 17 poster

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presentations in international/national meetings, being invited speaker in 3. I am also referee of the journals: J. Process Contr.; RIAI; Trends Food Sci. Tech.; Comput. Chem. Eng.; Ind. Eng. Chem. Res.; Chem. Eng. Sci.; Dry. Technol.; J. Sci. Food Agric.; J. Food Biochem.; and Int. J. Biol. Macromol.