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IRINEM

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3º Newsletter of the IRINEMA project

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January 2023, Madrid, Spain

<https://irinema.ietcc.csic.es/index.php/en/>

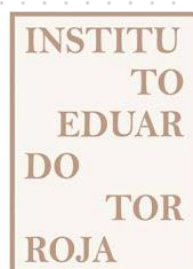
Welcome to the third IRINEMA newsletter!

We are pleasant to announce the third issue of the IRINEMA newsletters. With this new bulletin, we want to share the scientific knowledge derived from this third year of the project.

The IRINEMA project, "Immobilisation of nuclear-grade ion resins in alkali-activated materials" (2019- T1 / AMB-13672), is financed by the grants Atracción de Talento Investigador para la incorporación de personal investigador y realización de actividades de I+D, awarded by the Comunidad de Madrid. This project is carried out at the Eduardo Torroja Institute of Construction Sciences (CSIC).

The aim of this third issue is to share the main scientific contributions that have been made through IRINEMA in the third year of the project, as well as to highlight the work of the different collaborators who have contributed to it. In this publication, the reader will find an introduction about the studies carried out on the physical-mechanical and chemical properties of new cementitious materials for the immobilisation of spent nuclear grade resins, and a section dedicated to the companies, universities and research centres, which collaborate in the project, called "Our collaborators". In this third issue, we wanted to highlight the work of two collaborating centres, the National Centre for Biotechnology, CNB, and the University of Sheffield, UOS. Finally, there is also a list of news, meetings and conferences where IRINEMA has participated.

We hope that the interested audiences will enjoy the content of these newsletters.



IRINEMA


IRINEMA Results


During this third year of IRINEMA, the studies have been focus on the evaluation of the fresh and hardened state properties of the cementitious matrixes or geopolymers in presence of spent ion exchange resin to obtain complete and detailed information on its workability and its physicochemical properties. Regarding the fresh state properties, the rheological behaviour of the alkali activated cement formulations was studied to determine the effect of the addition of spent resins on the fluidity of this systems. Regarding the properties in hardened state, a series of studies have been carried out focused on the physical and chemical characterization of the cementitious matrixes in order to determine their dimensional stability and their transport properties in presence of the immobilised residue. For comparative purposes, these studies have also been carried out on a cementitious matrix with a similar composition to the one currently used in Spain to confine this type of radioactive waste.

The following tests have been carried out on the alkali-activated cementitious matrixes and on the reference system:

1. Study of the rheological properties with incorporated residue.
2. Evaluation of the physical properties: water absorption by capillarity, drying shrinkage and gas permeability.
3. Microstructural characterisation through X-ray diffraction, Fourier transform infrared spectroscopy, scanning electron microscopy and nuclear magnetic resonance.
4. Statistical analysis of the experimental results obtained.

This research activity has been completed thanks to collaborations such as those carried out with the CNB and the USO:

 CNB-IRINEMA collaboration to carry out a statistical analysis of the experimental results obtained from the behaviour in the fresh and hardened state of the geopolymer with incorporated residue. This study allows the modelling of the behaviour with the aim of optimizing the formulation that incorporates the maximum amount of residue while meeting the safety requirements.

 UOS-IRINEMA collaboration to carry out a study of the rheological properties of the alkali-activated materials in presence of ion exchange resins and thus determine the influence of the percentage of fly ash, the type of activator and the presence of the resin in the workability of the pastes.

These advances in the design of cementitious materials for the immobilization of nuclear-grade spent resins are deeply discussed in the scientific publications generated within the framework of the IRINEMA project in the last year:

- de Hita, M. J., & Criado, M. (2023). Influence of superplasticizers on the workability and mechanical development of binary and ternary blended cement and alkali-activated cement. *Construction and Building Materials*, 366, 130272.

[Construction and Building Materials, Influence of superplasticizers on the workability and mechanical development of binary and ternary blended cement and alkali-activated cement](#)

Or in the publications of IRINEMA in previous years:

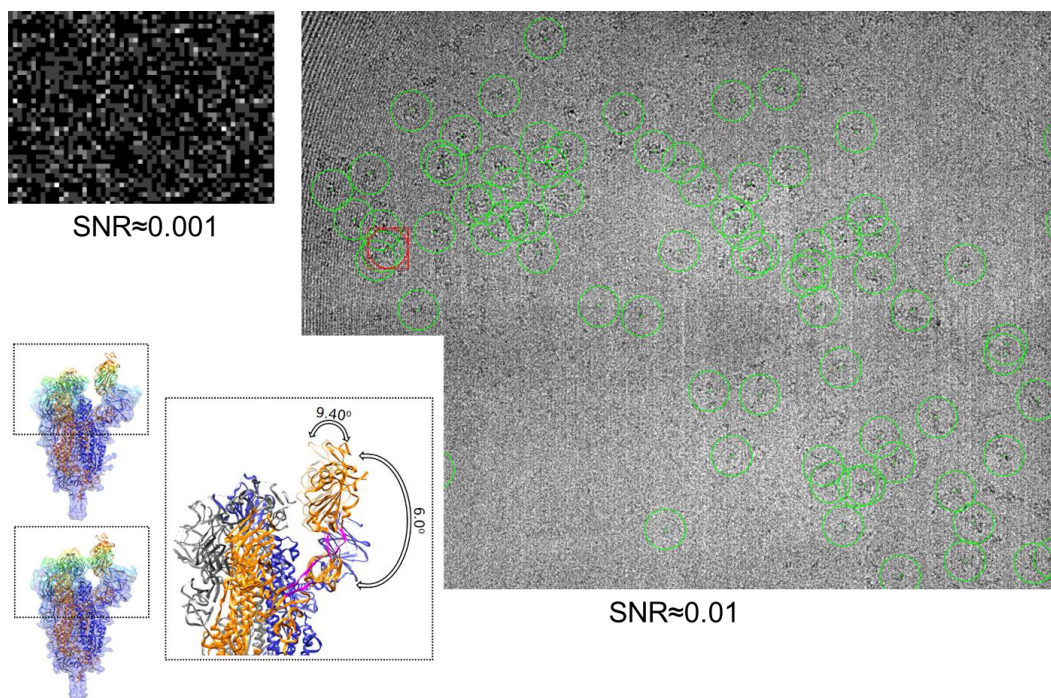
IRINEMA Results

- de Hita, M. J., and Criado, M. (2022). Influence of admixtures on the workability and strength of sodium carbonate-activated slag/fly ash cement. *Materials Letters*, 131695.
[Materials Letters, Influence of admixtures on the workability and strength of sodium carbonate-activated slag/fly ash cement](#)

- de Hita, M.J.; Criado, M. (2022) Influence of the Fly Ash Content on the Fresh and Hardened Properties of Alkali-Activated Slag Pastes with Admixtures. *Materials*: 15, 992.
[Influence of the Fly Ash Content on the Fresh and Hardened Properties of Alkali-Activated Slag Pastes with Admixtures](#)

CNB – IRINEMA Collaboration

The National Centre for Biotechnology (CNB) is a research centre that forms part of the Spanish National Research Council (Consejo Superior de Investigaciones Científicas, CSIC). In particular, the collaboration between the CNB and IRINEMA has been carried out through the CNB Biocomputing Unit. The Biocomputing Unit of the National Biotechnology Centre develops image and data processing algorithms for the analysis of information on the structures of biological macromolecules. This information is acquired using an electron microscope and has a signal-to-noise ratio (SNR) at of 1/1000 at the beginning, that is, there is 1000 times more noise than signal. After a first processing step, we can increase this signal to noise ratio by a factor of 10. These SNR-enhanced images are called micrographs in which the two-dimensional projections (as if contrasts) of the macromolecules must be identified. From these projections, we must apply some mathematical method implemented in a computer to reverse the projection process from 2D to 3D carried out by the microscope, so that the final result is the three-dimensional structure of the macromolecule under study. The following figure illustrates this process for the spike of the SARS-CoV2 coronavirus. This protein is the one that allows the recognition of our cells by the virus. Specifically, the enlarged area is mobile and is the receptor-binding domain, that is, the structure of the virus responsible for "anchoring" to our cells and penetrating them.



Coronavirus SARS-CoV2 spike

In order to extract the relevant biological information, we must design algorithms that are very robust to noise and develop strategies that allow the identification of errors in the estimated parameters. In general, statistics, signal processing and applied mathematics are at the base of all these algorithms.

IRINEMA Collaborations

These tools are transversal and multiple scientific disciplines can benefit from their use. In fact, we could almost said these are at the heart of any quantitative discipline. The knowledge of these tools allows the collaborations between CNB and IRINEMA, through the analysis of the experimental data obtained in mechanical strength, isothermal calorimetry and porosity tests, for the modelling and optimisation of the cementitious matrixes, thus highlighting the transversal nature of these tools and the possibilities of cross-fertilization by taking ideas and techniques from one scientific domain to another.



National Centre for Biotechnolgy (CSIC), Cantoblanco campus, Madrid.

The University of Sheffield – IRINEMA collaboration

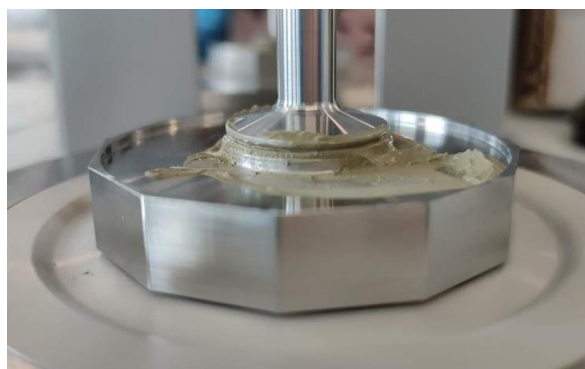
The University of Sheffield is one of the UK's leading universities, with more than 30,000 students across all areas of study, and a history particularly founded in the scientific and engineering heritage of the South Yorkshire region of England. The Cements@Sheffield



Department of Materials Science and Engineering housed in the Sir Robert Hadfield Building, Sheffield, United Kingdom.

research team has more than 40 members (academic, postdoctoral, PhD, and technical), and investigates cement materials science for applications in sustainable construction and nuclear waste immobilisation. The cement group develops many research projects involve alkali-activated and geopolymer binders, for use in construction and infrastructure, aiming to drastically reduce the CO₂ emissions footprint of the global construction materials industry.

The collaboration between the IRINEMA project and The University of Sheffield arises from the common objective of developing new cementitious formulations that are more environmentally friendly and can respond to problems that our society currently faces, such as sustainable waste management. In particular, the aim of the collaboration has been the rheological study of the new cementitious matrices that are being designed at IRINEMA. The study of rheological properties is of particular interest to the industry, since these properties will determine the processes that are needed for handling of the materials, which are essential for safe and cost-effective applicability at industrial scale. This study has been carried out using the cutting edge equipment of the Cements@Sheffield group, specifically an Anton Paar MCR 302e rheometer. Thus, the response of these materials in the fresh state to external stress or loads has been evaluated.



Evaluation of the rheological properties of cementitious materials in the facilities of the Cements@Sheffield group.

The 47th Annual Meeting of the SNE was held in the city of Cartagena from September 28 to 30, where current issues of great interest to professionals in the nuclear world were discussed. Dr. María Criado Sanz has represented the IRINEMA project by presenting the talk *Cinética de reacción de cementos activados alcalinamente para el almacenamiento de resinas gastadas de grado nuclear*.

News and Conference contributions

41st Cement & Concrete Science Conference



The 41st Cement & Concrete Science Conference organized by the University of Leeds and held from 12 to 13 September at Leeds, aimed to provide common ground for scientists and engineers from industry and academia on science of cementitious materials. IRINEMA has participated through the presentation by PhD student M^a Jimena de Hita of the work *Effect of the incorporation of spent nuclear grade ion-exchange resins on the reaction kinetics of alkali-activated slag-ash cement*.

IRINEMA at the National Congress of Materials, CNMAT 2022

From June 28 to July 1, the XVI edition of the National Congress of Materials organized by the Universidad de Castilla la Mancha was held in Ciudad Real, Spain. In this edition, IRINEMA has participated in the congress thanks to the presentation of Dr. María Criado *Inmovilización de residuos nucleares en matrices cementantes: efecto en la cinética de reacción y en el desarrollo mecánico*. The program of the conferences has included works of a high scientific level on the latest advances in processing, properties, characterization and behaviour of materials with applications in multiple technological fields.



Euratom FISA 2022 – EURADWASTE '22 Conference and Poster competition award

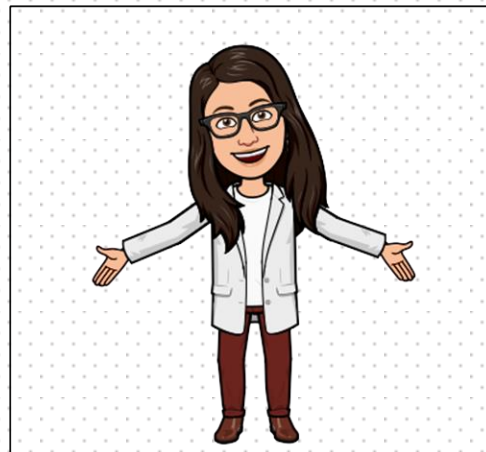
From May 30 to June 3, 2022, IRINEMA has participated in the 10th Euratom Conference on Reactor Safety & 10th Euratom Conference on Radioactive Waste Management organized by the European Commission and the CEA with the poster *Immobilization of spent nuclear grade resins in low carbon cement: study of the reaction kinetics* presented by PhD student Jimena de Hita. This event brings together different professionals from the nuclear sector, both researchers and representatives of regulatory bodies and the nuclear industry to discuss the state of the art of research in nuclear safety and waste management, the main challenges and opportunities and future prospects. IRINEMA has had the honor of receiving an award in the poster competition for its great scientific quality and originality.



News and Conference contributions

María Criado, PI of IRINEMA, in the Ranking of the 5,000 most outstanding Spanish and foreign scientists in Spain

The Consejo Superior de Investigaciones Científicas (CSIC) has published its first classification with the 5,609 Spanish and foreign scientists who research in Spanish organizations, classified according to the indicators of their public personal profiles in the Google Scholar database. In the first quartile of the ranking, specifically in position 1394, is Dr. María Criado, principal investigator of the IRINEMA project. The objective of creating this ranking is to increase the visibility of our researchers and their work using a public access tool that is easy to create and consult.



Participation in the International Day of Women and Girls in Science, 11F



IRINEMA has had the pleasure of participating in the commemoration of the International Day of Women and Girls in Science, on February 11. Dr. María Criado and the PhD student Jimena de Hita held a talk-workshop at the IES Gamo Diana with high school students to make visible the work of women scientists, thus creating female references for childhood that can contribute to the choice of STEM areas as professional careers.





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