LIFE REPLAY: A NEW LIFE FOR CERAMIC INKJET INK WASTE

Carmen Moreda[1] , Alejandro Gaya[1], Ana M. Molina[1], Carlos Vilar[1], Jorge González[1], Marina Llácer[2], Javier Gorris[2], Enrique Navarro[2],

[(1)] Instituto de Tecnología Cerámica (ITC). Asociación de Investigación de las Industrias Cerámicas (AICE) Universitat Jaume I. Castellón. Spain.
[(2)] Neptury Technologies. Almazora (Castellón). Spain.

ABSTRACT

The European ceramic industry is facing reindustrialization challenges to maintain its competitiveness and the sustainability of its processes. One of the most important enabling technologies is "inkjet printing", which has prevailed over traditional tile decorating techniques, significantly raising productivity, achieving a greater level of customization, increasing digitalization, and reducing manufacturing costs. The growing need to increase the digitalization of the ceramic tile production ("Full digital" objective) and to manufacture larger slabs leads not only to an adaptation of inkjet technology to these new formats, but also to the reformulation of new inkjet ink compositions. These new products allow the deposition of larger amounts, but they also include different solvents and pigments, which irremediably contribute to the generation of hazardous wastes from ceramic inkjet ink production and use. The process also generates industrial wastewater from the cleaning stages.

Nowadays, inkjet ink waste management consists of a chemical separation (coagulation-precipitation settling mechanism), followed by a physical procedure of solid separation using a filter-press prior to landfilling.

The current procedure is underperforming, for both wastewater and pigment-based slurries, due to drawbacks in dealing with organic-based suspensions and small particle sizes (which are specific to inkjet application). The subsequent "non-complete" separation makes it extremely difficult to industrially reuse the solid and the liquid effluent contained in ceramic inkjet ink wastes.

This work is part of a European LIFE project, called LIFE REPLAY (LIFE20 ENV/ES/000115), the main goal of which is to demonstrate the technical feasibility of using ceramic inkjet ink waste as a new raw material for the ceramic industry, after previously separating such waste into a solid component based on heavy-metal inorganic pigment and a liquid component based on an organic solvent.

1. INTRODUCTION

In 2019, about 2400 tonnes of waste were generated from ceramic inkjet inks at European level without being re-used or recycled. Their treatment and disposal induce costs of about 14.4 M€/year at European level. The two leading countries at EU level in terms of production and waste generation are Spain (641 t/year) and Italy (503 t/year), representing a total cost above 6M€/year.

Ceramic inkjet inks are generally made up of complex mixtures consisting, mainly, of a heavy metal-based solids component comprising (singly or jointly) inorganic pigments/refractory materials/ceramic frits (25–55 wt%), organic solvents (45–65 wt%), and different additives (1–10 wt%). The presence of heavy metals (such as Ni, Pr, Cr, Co, and Fe) in the solid component and the organic nature of the solvents (paraffinic and, naphthenic oils, ester, glycol-ether, etc.) used in the formulation entail important environmental problems, increasing health and environmental risks (i.e. soil and water contamination).

The hazardous uncertainty of the waste generated and the economic cost of waste treatment and disposal oblige the ceramic industry to take appropriate actions to prevent and/or minimize waste generation, to increase resource efficiency and to mitigate negative impacts.

Indeed, the European Commission implemented the Directives 2008/98/EC, 2014/957/EU, and 1357/2014 on wastes, as well as COM(2015) 614 final on circular economy. The different communitarian countries adopted, therefore, these strategies by means of specific regulations. In Spain, a draft law (APL/2020) was established to transpose the EU directives; and in Italy and Bulgaria, the Law 221/2015 and LEX-FAOC164398 (2016) respectively were accordingly approved and implemented.

Despite this fact, the difficulties related to the separation process, the sub-micron particle sizes required, and the non-aqueous nature of the solvents present in the ceramic inkjet ink wastes are countries' main constraints and limitations to meeting regulatory requirements.

Thanks to LIFE REPLAY, ceramic inkjet ink wastes will be reintroduced into the industrial process by using a specific separation procedure which meets industrial quality management requirements. The promotion of sustainability and, hence, the minimization of waste disposal costs are the main goals of this project. The project will also demonstrate the feasibility of using inkjet ink wastes as new raw materials for the ceramic industry, transforming them into an environmentally friendly and cost-effective alternative source of pigments and solvents.

2. PROJECT OBJECTIVES

The project's main goal is to demonstrate the technical feasibility of using ceramic inkjet ink waste as a source of new raw materials (by-products) for the ceramic industry, after previously separating such waste into a solid component based on heavy-metal inorganic pigments and a liquid component consisting of organic solvents.

The project LIFE REPLAY envisages the following specific objectives:

1) To demonstrate in a real environment the valorization of inkjet ink waste in ceramic SMEs.
2) To implement a value chain pilot based on circular economy pillars through industrial symbiosis among SMEs.
3) To demonstrate the competitive edge of the business model and measure the economic benefits for all SMEs, especially those related to the ceramic, decorative glass, and cathodic/anodic application industries.
4) To develop a prototype for the separation procedure of the inkjet ink waste in a simple and low-cost process.
5) To deploy the new business model for the transformation of inkjet ink waste as a new resource for the ceramic industry.
6) To assess the environmental impact on the production of brand-new ceramic products by reusing and recycling inkjet ink waste, as well as on ceramic tile and inkjet ink production.
7) To replicate the solution of the innovative valorization scheme in other ceramic SMEs (not only the consortium).
8) To transfer the solution to other SMEs devoted to other sectors/application areas.
9) To foster social awareness related to the environmental problems caused by inkjet ink wastes, comparing the current situation with the new situation after this project.

3. RESULTS

3.1 PHYSICAL-CHEMICAL SEPARATION PROCESS

The results obtained so far show the successful implementation at pilot plant level of a prototype for separating waste into its solid part and liquid effluent.

For the reintroduction of both products obtained from the separation, an ink is developed that incorporates solid waste into its formulation, as well as the creation of a screen printing ink with the liquid effluent.

Figure 2. *First inkjet ink developed valorizing the by-products obtained through LIFE REPLAY implementation*

Figure 1. *First screen-printing ink composition developed valorizing the by-products obtained through LIFE REPLAY implementation.*

4. ACKNOWLEDGMENTS

This project is financed by the LIFE Programme 2014-2020 of the European Union for the Environment and Climate Action under project number LIFE20/ENV/ES/000115. The project is also co-financed by the Autonomous Government of Valencia(GVA), through the Valencian Institute for Business Competitiveness (IVACE).