RFID tags study case

E-printed paper production and characterization

- Ink characterization;
- Screen-printing;
- Ag Extraction by successive leaching, concentration and recovery

Determination of Ag extraction efficiency (%EE):
\[
\%EE = \left( \frac{C_{\text{final}} - C_{\text{initial}}}{C_{\text{initial}}} \right) \times \frac{V_{\text{initial}}}{V_{\text{final}}} \times 100
\]

where, \(C\) (mol·L\(^{-1}\)) and \(V\) (L) correspond to concentration and volume, respectively.

Evaluation of the following parameters:
- Nature and concentration of leaching agent;
- Volume ratio;
- pH;
- Different molar ratios;
- Different metal ion concentrations;
- Multicycle extraction;
- Stripping (back-extraction) efficiency.

Context
Circular Economy
Fibers and metal particles valorisation
- Elimination of waste and pollution production;
- Keep products and materials in use;
- Regenerate natural systems.

Resulting in:
- Business and economic opportunities;
- Job creation;
- Environmental and social benefits.

Waste of electrical and electronic equipments (WEEE)
Commonly designated as e-waste.

Printed Electronics (PE)
- Low-cost production;
- Large-area flexible devices;
- Reduced resources usage;
- Global PE market (2020) = 7.8 b USD
- Expected to grow in 2050 = 20.7 b USD
- Recyclable?

Electronics on paper
- Low price substrate;
- Simple fabrication methods;
- Lightweight;
- Flexible and can be folded into 3D structures;
- Biocompatible, biodegradable, and environmentally friendly;
- Porous material (high surface area-volume ratio).

Objectives
Selection of the raw materials
- Functionalized inks;
- Paper grades;
- Production of model printed functionalized electronic device.

Separation of inks from cellulosic fibers
Deinking Process – several unit operations

Analysis of all produced fractions
Evaluation by mass balance (MB)
In separation processes, usually, there are no reactions, so MB can be described as:
\[
\text{Input} = \text{Output} + \text{Accumulation}
\]

Separation, recovery and valorisation of all materials
- Implementation of a new separation and recovery strategies;
- Valorisation study of recovered materials:
  - Papermaking ability of cellulosic fibers;
  - Quality of the recovered metal particles – possible valorisation

Methods
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E-printed paper production and characterization
- Ink characterization;
- Screen-printing;
- Optical 3D measurement system for surface characterization (Alicona).

Development of Recycling Process – unit operation investigation
- Mass balance;
- Ag tracking;
- Fiber analysis.

Ag Extraction by successive leaching, concentration and Recovery

Commonly designated as e-waste.

Optical 3D measurement system for surface characterization (Alicona).

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