

# Valorization of spent coffee grounds - tannin recovery



M.A. Vilar<sup>a</sup>, W. Júnior<sup>a</sup>, N. Caetano<sup>a,b,c</sup>

<sup>a</sup>CIETI, School of Engineering (ISEP), Polytechnic Institute of Porto (P.Porto), R. Dr. António Bernardino de Almeida 431, 4249-015 Porto, Portugal

<sup>b</sup>LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy, Faculty of Engineering, University of Porto (FEUP), R. Dr. Roberto Frias s/n, 4200-465 Porto, Portugal

<sup>c</sup>ALiCE - Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

## Introduction



Figure 1: Spent coffee grounds (SCG) in capsules and from cafeterias

The high coffee consumption in the world makes its waste, spent coffee grounds (SCG), one of the most abundant kind of waste in the world. This residue presents an extremely high contamination potential due to the toxic compounds that constitute it (tannins, caffeine, polyphenols, etc.). The disposal of this waste, many times made in uncontrolled conditions, represents a big and dangerous risk to the environment. Disposal in landfills or burning in Municipal Solid Waste incinerators represents a loss of value (loss of nutrients or valuable compounds), while composting that allows nutrient recovery adds little value due to the high production and low compost cost. This work aimed to evaluate the potential for valorization of spent coffee grounds, namely through tannins recovery. Thus, in this work it was optimized the extraction conditions of tannins in SCG samples from different origins (SCG from espresso capsules, SCG from restaurants and cafeterias – standard SCG, etc.), testing processes for the recovery of tannins and their conversion to tannase. Subsequently, it was optimized the process for tannins recovery from the SCG, as a potential solution for SCG management, while extending the life of coffee within a circular economy framework.

## Results & Discussion

In the first phase of the work, the varied parameters for tannins extraction were the following: type of sample (SCG from cafeterias, SCG from capsules); type of solvent (acetone 70% (v/v), methanol 80% (v/v), ethanol 70% (v/v) and water); extraction temperature (50 °C and TA (21-23 °C)); wet or dried SCG. All tests performed with 1 h of extraction time. In addition to the previous tests, also tested 2 h extraction time; extraction of a SCG sample with 53% moisture content; and an extraction with ethanol 70% (v/v) in 2 consecutive contacts of 1 h contact time each.



Figure 2: Samples after 1 h extraction with water

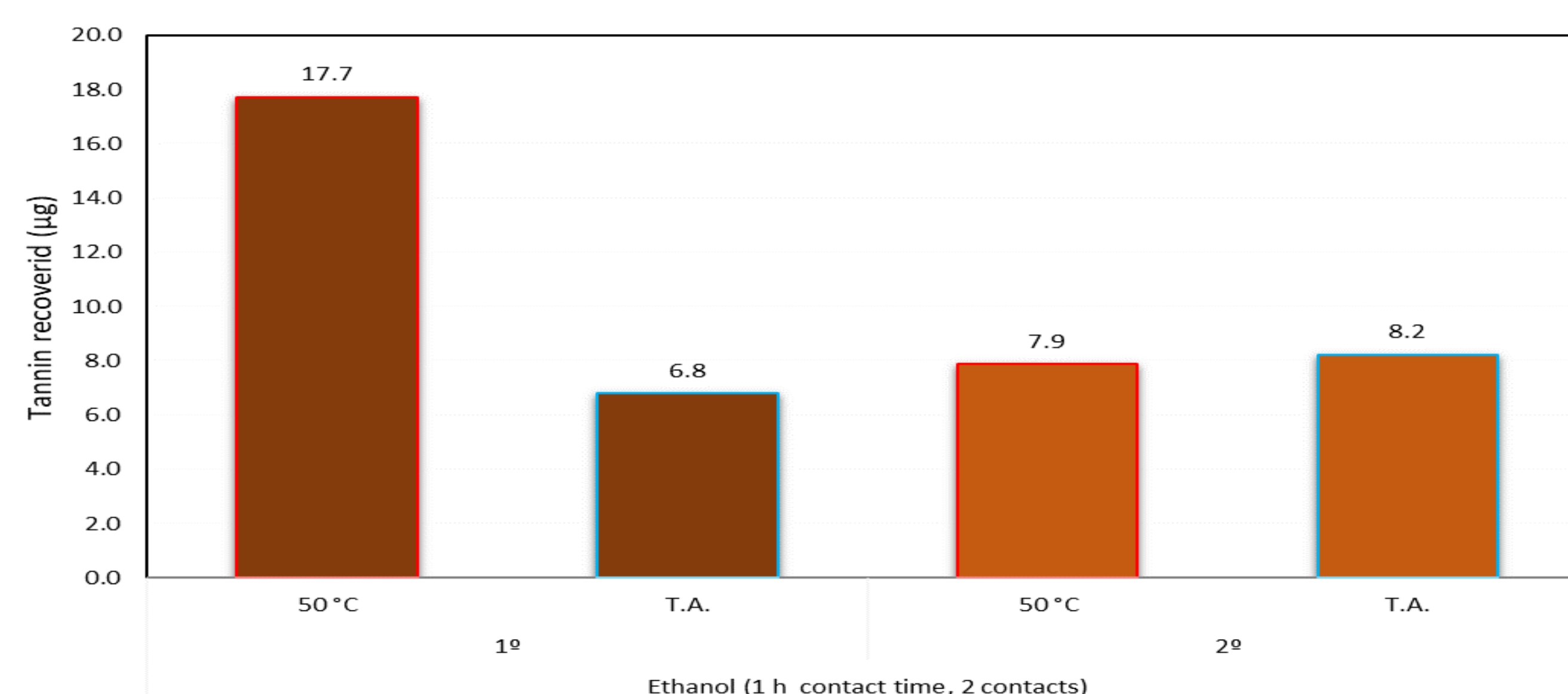


Figure 4: Results of extraction of tannins from a 40 g sample of wet SCG (53% moisture) using ethanol in two consecutive 1 h contacts

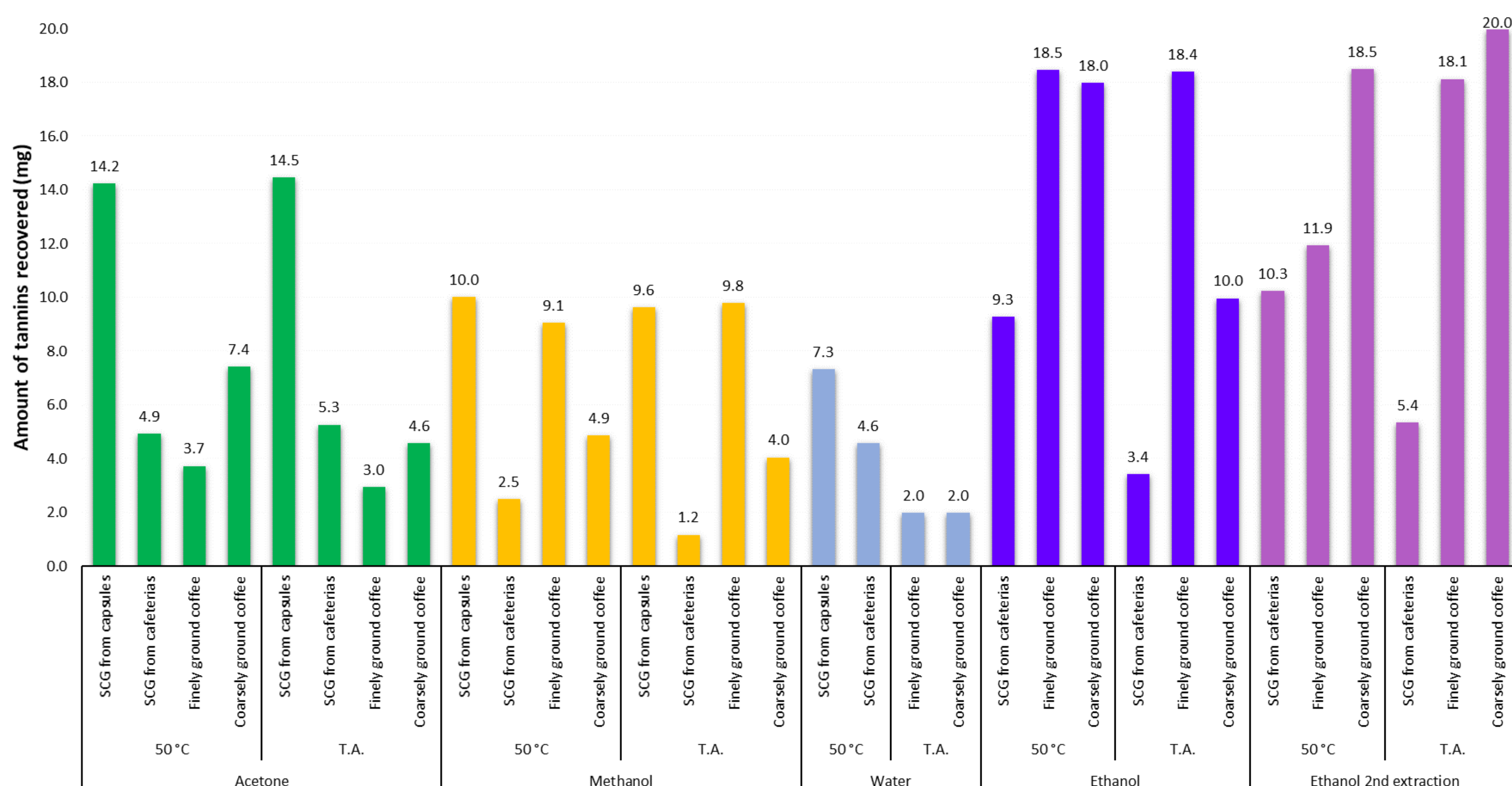


Figure 3: Tannins recovered from 40 g (dry weight) SCG using different solvents and extraction temperatures. For the samples extracted with ethanol, a 2<sup>nd</sup> extraction step was also tested

Comparing the results obtained in the present work with those in the literature for other feedstock:

- cashews - tannin extraction yield of 0.35 - 0.72 %,
- cassava - tannin extraction yield of 0.62 - 1.11 %,
- acacia wood - tannin extraction yield of 2.77 %,
- SCG - tannin extraction yield of 0.02%
- this work yielded 0.064% tannin extraction

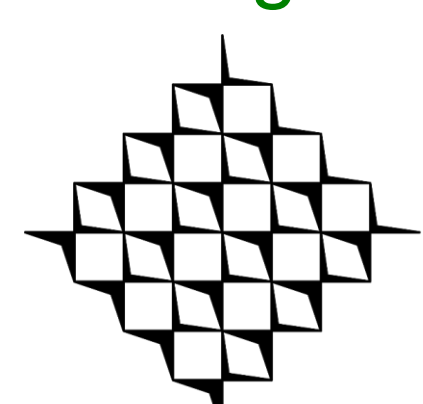
SCG yields lower tannin yield than other sources, but the present conditions yielded 3 fold the extraction yield reported in the literature for SCG.

In Portugal with a population of 10,297.1 thousand inhabitants, with an average of 4.4 kg of coffee consumed per person per year, and considering that only 80% of the coffee is consumed in cafeterias, 36,247.8 tons/year of SCG are produced. If the SCG has 53% moisture, 68,388.3 tons/year of wet SCG are produced.

It can be estimated that it would be possible to extract and recover about 16,040 kg of tannins/year. For this purpose, it would be necessary to collect the SCG and transport them to tannin extraction units, which would use ethanol 70% (v/v) as solvent, at a temperature of 50 °C, SCG with a moisture content of 53% and two extraction steps with a contact time of 1 hour each.

## Conclusion

The best combination of conditions for tannins extraction from SCG were: SCG collected from cafeteria with a moisture content of 53%, extracted using ethanol (70% v/v) as the solvent, at a solid to liquid ratio of 800 g: 1 L, at a temperature of 50 °C, with two consecutive contacts of 1 hour contact time each. The highest tannin recovery was 640 mg of tannins from 1 kg of SCG, that is 0.064%, about 3 fold the yield previously reported.



**Lepabe**  
Laboratory for Process Engineering,  
Environment, Biotechnology and Energy



ASSOCIATE  
LABORATORY  
IN CHEMICAL  
ENGINEERING



UNIVERSIDADE DO PORTO  
FACULDADE DE ENGENHARIA



**cieti**  
centro de inovação  
em engenharia  
e tecnologia industrial



## Acknowledgements

This work was financially supported by: LA/P/0045/2020 (ALiCE) and UIDB/00511/2020 - UIDP/00511/2020 (LEPABE) funded by national funds through FCT/MCTES (PIDDAC);

