URBAN SEWAGE SLUDGE VALORIZATION TO BIODIESEL PRODUCTION:

LIPID EXTRACTION THROUGH ADSORPTION ON SPUNBONDED NONWOVEN-POLYPROPYLENE

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In response to the global demand for fossil fuels, the decrease in fossil fuel reserves and climate change, scientific research is focusing on alternative fuel sources, such as biodiesel, commonly known as FAMEs (Liu et al., 2021). Among the starting materials for the obtainment of biodiesel, urban sewage sludge is a very promising feedstock, presenting an abundant content of lipids at a reasonable cost, considering that sewage sludge is an urban waste deriving from the wastewater treatment process. The classical method of recovery of lipids from the (desiccated or dewatered) sludge is based on the extraction using n-hexane (Olkiewicz et al., 2014; Pastore et al., 2013), by generating an exhausted sludge wet of organic solvent. Therefore, the most important issue related to the recovery of lipids from sludge is the optimization of a clean route, possibly avoiding the direct contact of organic solvents with the sewage sludge.

In this work we studied the extraction of the lipid component from sewage sludge, to produce FAMEs, through the physical and chemical adsorption on surfaces composed of non-polar polymeric materials (Schadock-Hewitt et al., 2015). After preliminary testing some commercial polymers, Spunbonded nonwoven polypropylene (s-nw PP) was deeply investigated. The commercial product SP30-001 IDR (having grammage 30 g/m^2, tensile strength MD 65 N/50mm, elongation MD 60%, tensile strength CD 60 N/50mm, elongation CD 70%, tear strength MD/CD 32 N) was preliminary used for this study.

Figure 1 describes the main experimental operations used for this solvent-free recovery of lipids and grease: **a)** s-nw PP was kept in contact for 10 minutes in a known amount of sewage sludge at 343 K; **b)** s-nw PP was then recovered from sludge, dried and washed with acidified methanol; **c)** s-nw PP was reused for a new cycle of adsorption on a fresh sewage sludge sample, whereas the methanolic solution derived from step was evaporated, releasing an extract (ME), on which FAMEs content were gas-chromatographically quantified.


1a)

1b)


1c)

Figure 1. Experimental layout related to the recovery of grease and lipids from acidified sludge using s-nw PP sheet.

Figure 2 shows the MICRO-ATR-FTIR spectra recorded on s-nw PP at the end of each processing step: after the contact with the (acidified) sludge, besides the reticular structure of the s-nw PP, some brown spots were observed, typical of the adsorbed sludge. In detail, the MICRO-ATR-FTIR signal of the carbonyl group of fatty acids at 1700 cm^{-1} was detected; after washing with acidified methanol, the intensity of this absorption decreased while, on the contrary, a signal at 1741 cm^{-1}, attributable to the methyl esters of fatty acids, increased considerably.

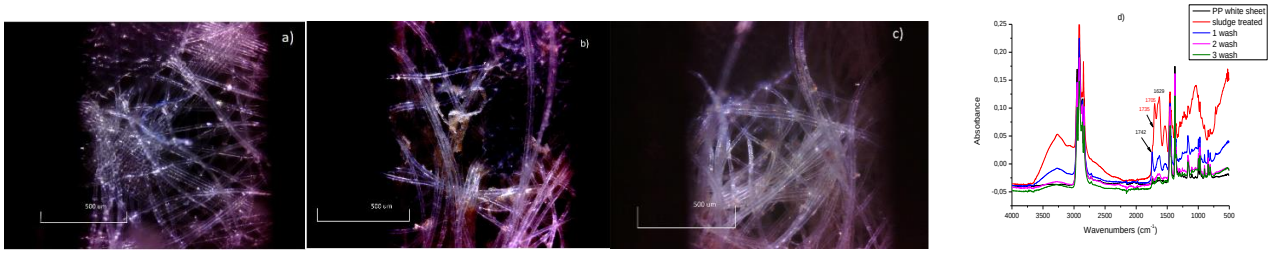

Figure 2. Microscopic images of **a)** s-nw PP vergin sheet, **b)** s-nw PP sheet before adsorption, **c)** s-nw PP sheet after MeOH washings; **d)** ATR-FTIR on PP layers during the experiment.

The influence of starting pH of the primary sewage sludge, sampled from the wastewater treatment plant located in Putignano (Puglia, TS: 6.9%, Lipids: 24.6%$_{TS}$, FFAs: 17%$_{TS}$), on the recovery of the esterifiable lipid fraction was initially evaluated.

An enrichment of free fatty acids on the surface of the s-nw PP sheets can be achieved and the lipids can be recovered and simultaneously esterified with acidified methanol to obtain FAMEs; the extraction yield of the lipid component were significantly influenced by the pH and the weight ratio R, defined as "s-nw PP sheets weight/initial wet sludge weight*100" and decreases with the number of processing cycles.

There is a significant improvement in the extractive performance, due to the acidification of the sample. The FAMEs content in ME for an R of 3% was 22.4% for primary sludge at pH 6.9, with a yield of recovery of FAMEs of 6.6% (with respect to the esterifiable lipids initially present into the sewage sludge). The adsorption on the s-nw PP sheet of calcium soaps of fatty acids was evidenced by the ATR-FTIR analysis. Signals located at 1575 cm^{-1} and 1539 cm^{-1} typical of calcium soaps were recorded (Poulenat et al., 2003). Meanwhile, when the urban sewage sludge was preliminarily acidified through the addition of HCl conc. (pH 1.2), using a R of 3%, a higher FAMEs recovery yield (24.1%) was achieved, with a significant FAMEs enrichment (2.3 times) in the ME fraction (39%).

Finally, a clear improvement in recovery yields was obtained working with a R of 6%: a FAMEs recovery yield of 38.8% was obtained by collecting a ME with a FAME content of 33.9%. These effectiveness of the s-nw PP extraction was confirmed by evaluating the residual lipid content on the exhausted sludge at the end of each cycle obtained through extraction with n-hexane.

After the first cycle the s-nw PP sheets were reused with a significant loss of extraction efficiency: this is due to the presence of dried residual material on the polymeric surface, gravimetrically quantified and spectroscopically characterized, which is not solubilized during the two subsequent washes with acidified methanol.

In conclusion, s-nw PPs recovered from used surgical masks, widely adopted as a prevention device against the pandemic virus Sars Cov 2, were directly studied as adsorbent by obtaining congruent results with respect to that ones obtained by using virgin s-nw PPs. In this way, the valorization of sewage sludge for the synthesis of biodiesel could be achieved using another waste, with a promising and much greener perspective than the conventional extraction based on the use of organic solvents.

References

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