

Bioconversion of municipal solid waste into lactic acid

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Introduction

Renewable resources can be converted biotechnologically by enzymes and microorganisms, giving us access to a multitude of biocompatible products and possible uses. The carbon sources from agricultural feedstocks, side-streams and residues can be utilized to produce lactic acid (LA). Lactic acid, its salts and esters have a wide range of potential uses and are extensively used in diverse fields [Alves de Oliveira et al., 2018].

Besides the quantity and availability of raw materials together with their properties and quality the feedstock costs are very important for the production of bulk chemicals like lactic acid [López-Gómez et al., 2018]. The here presented research is part of an ongoing EU project (PERCAL, <http://percal.aimplas.es/index.php>) which deals with the valorization of the biogenic fraction of municipal solid waste (MSW). The organic fraction of MSW (OMSW) consisting of carbohydrates, proteins and lipids will be used as fermentation substrate in order to obtain higher-value products (e.g. ethanol, lactic acid and succinic acid) followed by subsequent processing into solvents, hot-melt adhesives, and polyols. With regard to a cascading and entire use of the feedstock fractions that remain after these fermentation processes will be used for biosurfactant production as depicted in Figure 1.

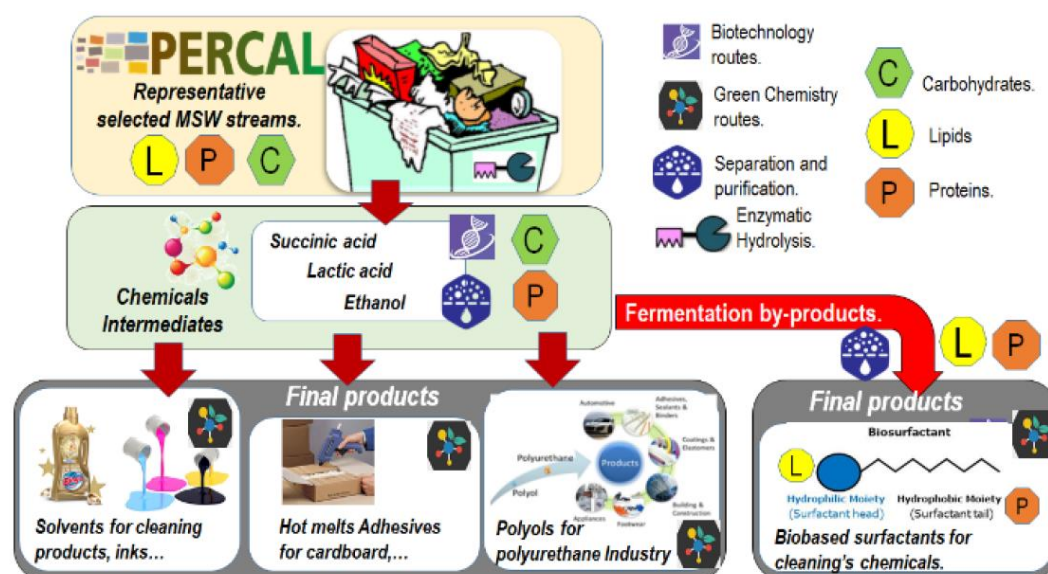


Figure 1: PERCAL Flow Diagram including intermediates and sectors involved in each step.

Feedstock preparation

There are some steps of pre-treatment and enzymatic hydrolysis necessary before using the substrate, rich in both carbon and nitrogen sources, for the fermentative production of L-lactic acid. In addition of that toxicity assays of selected MSW hydrolysates were performed to identify disturbing impurities and/or inhibiting compounds which could be released during the before mentioned pre-treatment steps. Table 1 shows the concentrations of sugars and LA for the three different batches used for the toxicity analysis.

Table 1: Batch from different sources OMSW hydrolysate used for the toxicity assays in LA fermentations. The table includes the concentration of sugars and LA for each batch

Batch	Source	Concentration (g/L)				
		Glucose	Disacch	Fru/Xyl/Gal	Arabinose	LA
A	Non separately collected biowaste	52.5	6.46	10.1	1.13	5.69
B	Separately collected biowaste	52.9	6.56	10.2	1.15	5.72
C	Biowaste + paper/cardboard	29.6	4.0	5.9	0.3	17.9

The table also includes the source from where the hydrolysates were produced. As seen, there is a big difference in the concentrations of sugars obtained from the mixture of biowaste and paper/cardboard and the first two batches from biowaste only. Furthermore, batch C also showed a concentration of lactic acid around 3 times higher than batch A and B.

Results & Discussion

Pre-treated OMSW was used as the substrate for fermentations with several *B. coagulans* isolates. The experiments were carried out using small scale bioreactors with a working volume of 0.4 L. In the first one the hydrolysate was filtered with a sieve (150 μm), in the second one the hydrolysate was centrifuged for 15 min at 10 000 rpm. Glucose was almost completely depleted after 12 h for the filtered hydrolysate. The consumption of other sugars such as xylose, fructose and galactose (according to table 1) continued until being depleted for the filtered sample while the consumption of them stopped at 30 h for the centrifuged sample. LA production started with any apparent lag phase and reached a maximum concentration of 65 g/L for both samples. Considering that the initial concentration of LA in the samples was around 15 g/L a net increment in the concentration of 50 g/L was observed. It is apparent that, regardless of the method for the removal of solids, fermentation results are similar and that there is no advantage of centrifuging the hydrolysate over only filtering it. Initial total sugars concentration was around 65 g/L for both the filtered and the centrifuged hydrolysates. A conversion of sugars of around 75% was observed in both cases when taking into consideration the total initial sugars. However, some of those sugars are very difficult to metabolize by the bacteria as in the case of some disaccharides.

Further substrate optimization tests were carried out with different steps of filtration and separation in order to remove impurities to allow for a highly pure L-lactic acid. Several thermophilic strains were screened to evaluate lactic acid productivities at 52°C. Fermentation results showed that, for most of the isolates, conversion yields were higher than 0.80 g LA/g sugars. Furthermore, substrate optimization resulted in a final product with an optical purity of L-lactic acid of more than 99%. Experimental work has demonstrated that the hydrolysate from OMSW is a good substrate for the production of lactic acid with a total sugars concentration in the hydrolysate exceeding 70 g/L in some cases. Several LA producing strains were tested with promising results in terms of yields and productivities. Furthermore, the hydrolysate is able to support the growth of the bacteria without the addition of any other nutrients and without any apparent inhibitory effects.

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