Volatile Fatty Acids production as PHAs precursors from candy manufacturing wastewater

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Human and industrial activities consume high volume of used water causing more and more impact and problem of global warning, due to the increase of greenhouse gases in the atmosphere. The European economy depends on oil and gas for the chemicals and energy sectors and for all kinds of everyday products. However, bio-based products, like volatile fatty acids (VFAs) and polyhydroxyalkanoates (PHAs), can be substituted for fossil-based materials and bring new functionalities to the market, making the economy more sustainable and reducing its dependence on fossil resources (EC, 2019). Industry, supported by governments and large research programmes such as Horizon 2020, has developed an array of innovative bio-based products, which are expected to find their way onto the market in increasing numbers. Among the others, the Horizon 2020 BBI JU AFTERLIFE project (Figure 1) aims to foster promising and innovative wastewater treatment from food industry in order to recover compounds of interest and the conversion of the rest of the organic matter into a high-volume added value biopolymer.

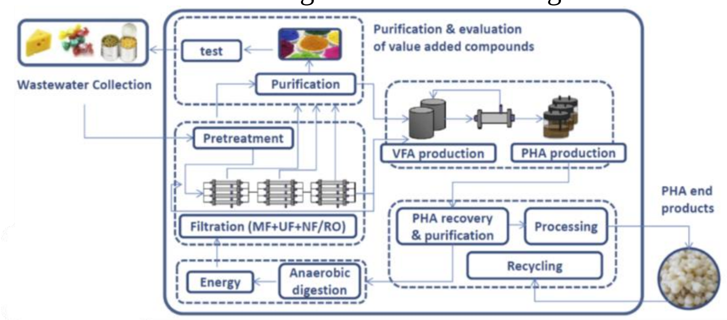

Figure 1 The AFTERLIFE concept

AFTERLIFE process is embedded in a circular economy approach through the reuse of the outlet water and the valorisation of the organic matter by the recovery and purification of high value added compounds, the conversion into value added products and the generation of energy and clean water to be used within the process. The process will be assessed for its technological, environmental and economic feasibility at industrial scale.

In line with this approach, Innoven Srl is in charge for the investigation of the VFAs production through acidogenic fermentation from candy manufacturing wastewater (CMW). In this work, different parameters were analysed in order to evaluate the optimal conditions of pH control and type of inoculum in order to maximize the VFAs concentration. In table 1, the characteristics of the candy manufacturing wastewater are shown. CMW presents low content of nutrients in relation with the concentration of COD. The latter is mainly in soluble form due to the high presence of residual sugars derived from the cleaning and washing operations of the candy manufacturing.

Table 1. Chemical and physical analyses of the CMW.

Parameter	**Unit**	**Value**
Total Solids (TS)	%	7.9
Ratio TVS/TS	%	96
Total COD	gCOD/L	97.4
Soluble COD	gCOD/L	88.2
TKN	mgN/gTS	23.2
NH_4-N	mgN/L	0.9
TP	mgP/gTS	2.9

Fermentation batch test at mesophilic conditions (37°C) were carried out in triplicate for each conditions using bottles with 1 L of working volume. Two different type of inoculum were used to inoculate the bottles. The first inoculum was anaerobic digestate taken from a full scale biogas plant of agricultural residues, while the second was activated sludge from municipal wastewater treatment plant (WWTP). The pH was adjusted at the beginning or controlled at the set-point value (Table 2) during the whole batch period (around 7 days). Two type of inoculum were selected in order to investigate the time required for the acclimation of the biomass: 1) anaerobic digestate taken from biogas plant of agricultural residues; 2) activated sludge taken from municipal WWTP.

Table 2. Operating conditions of the fermentation batch test

Batch tests	Description
pH	5.5; 7; not controlled
	Buffered
Type of inoculum	Activated sludge from municipal WWTP Anaerobic digestate from biogas plant (treating agro-waste materials)

The highest VFAs concentration were observed after 4 days of fermentation for all the batch performed. The type of inoculum influenced the rapidity of biomass for acclimation. Although after 7 days both inoculum showed similar VFAs concentration (data not shown), the batch test inoculated with anaerobic digestate from agricultural residues showed higher concentration compared with the activated sludge.
As regard as the effect of pH, generally the VFAs concentration linearly increased when the pH increased from around 5 to 7 (Crutchik et al., 201. However, the pH control strongly influenced the VFAs concentration. When the pH was adjust only at the beginning of the batch, the concentration increased from 4306 to while 8683 mgCOD/L, while when the pH was buffered during the fermentation batch test, the VFAs concentration increased from 17688 at pH 5, up to 23726 mgCOD/L at pH 7. During the batch, the resulted mixture of VFAs were composed mainly by acetic, propionic and butyric acids. However, at lower pH (not controlled), acetic a butyric acids were the most abundant type of VFAs (49% and 44% respectively). At higher pH (pH 7), the presence of propionic acid increased up to 21%, while acetic decreased to 30%.

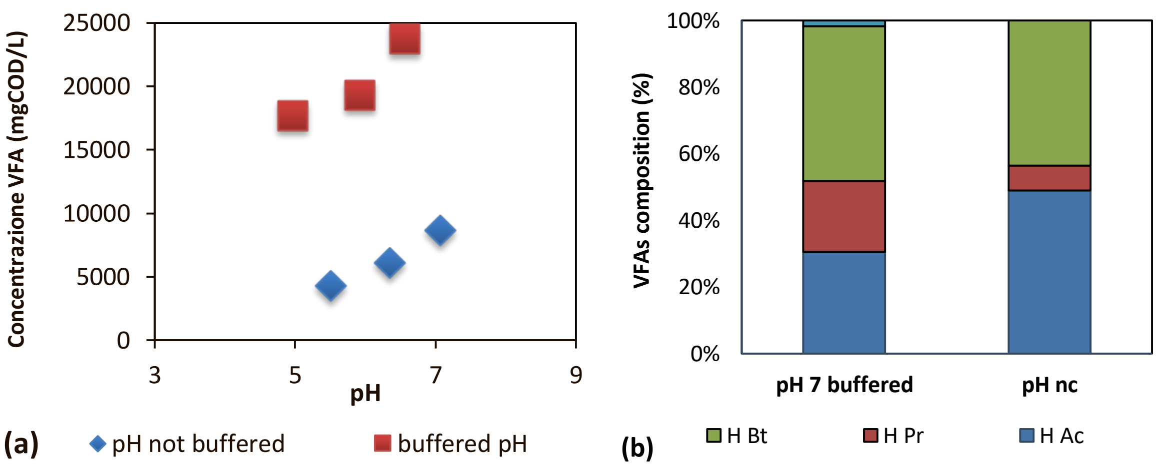

Figure 2 (a) Effect of pH control on the VFAs concentration; (b) Effect of the pH control of the VFAs composition

Further investigations are in progress with the aim to concentrate and purified the VFAs produced in order to enable different uses according with the desired quality of the final bio-based product.

Literature

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