Fermented Municipal Biowaste as Source of Value Added Chemical Specialities and Intermediates.

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The anaerobic digestate (AD) and compost (CP) sampled from a municipal biowaste (MBW) treatment plant (www.aceapinerolese.it), as source of soluble biobased substances (SBO), have been studied at the University of Torino over the past 13 years. The SBO, isolated from the alkaline hydrolysates of AD and CP (www.biochemenergy.it), are biopolymers with molecular weight from 70 to over 750 kDa. They contain aliphatic and aromatic C chains substituted form a variety of acid and basic functional groups. They have been reported promising chemical specialities for multiple uses (Montoneri, 2017), e. g. the formulation of detergents, textile dyeing baths, flocculants, dispersants and binding agents for ceramics manufacture, emulsifiers, auxiliaries for soil/water remediation and enhanced oil recovery, nanostructured materials for chemical and biochemical catalysis, plastic materials, soil fertilizers and plant biostimulants for agriculture, and animal feed supplements. Depending on the application, the AD and CP SBO exhibit different performance one from the other. The results offer the perspective to turn a municipal biowaste treatment plant into a biorefinery integrating biochemical and chemical technology to produce biofuel and a range of valued added bio-based chemicals, tailored to specific uses. To upgrade processes, properties and uses for the above SBO, work is in progress at the University of Torino. Specifically, the following processes are being investigated : (i) SBO assisted anaerobic fermentation of biowastes; (ii) AD and CP oxidation and hydrogenation.

The SBO assisted anaerobic fermentation addresses ammonia as major problem in anaerobic digestion of municipal biowaste, manure and waste water treatment (WWT). Ammonia concentration in biologically treated WWT is generally 12-35 mg/L (Gang, 2002). Depending on source, three concentration ranges are found: < 100 mg /L in domestic wastewater, 100-5000 mg /L in sludge liquor, > 5000 mg/L (Mulder, 2003). Ammonia in municipal biowaste liquor (Francavilla *et al*, 2016) and in cow manure (Riggio *et al*, 2017) has been found 1.2-1.4 g/L. Ammonia poses problems for disposal and/or use of waste water and digestate from urban and agriculture source. For example, the Directive 91/676/EEC of 12 December 1991 (Council Directive, 1991) concerning the protection of waters against pollution caused by nitrates has introduced the concept of vulnerable zones in which the application of N-containing wastes is limited. The Italian legislation (Regione Veneto, 2016) has established a maximum 340 N kg/ha.yr that can be applied to soil. Thus, waste water and digestate must be treated to reduce and/or remove ammonia before use. A number of biochemical and chemical processes for ammonia removal have been developed to meet stringent discharge norms (Sabumon, 2009). These processes require high CAPX and OPEX costs (Francavilla *et al*, 2016). Recently, the CP SBO have been reported to decrease ammonia content in the anaerobic digestate from urban biowastes (Francavilla *et al*, 2016) and cow manure (Riggio *et al*, 2017), when added at 0.05-0.2 % concentration in the fermentation slurry feed. Based on these findings, and within the funded LIFECAB LIFE16 ENV/IT/000179 project, a prototype SBO production facility is under construction. It will be installed in the Pinerolo Acea waste treatment plant. It will produce enough SBO to be added to the 2600 m^3 Acea anaerobic bioreactor. It aims to validate the SBO effect under real operational conditions. Concurrently, R&D work is in progress to assess the mechanism and fate of ammonia removed in the SBO assisted fermentation.

The aim of AD and CP oxidation and hydrogenation processes is broader. The strategy will reproduce the one used in fossil chemistry technology. Development of sustainable biowaste processes and products is according to the following guidelines. Processes must achieve high products' yield with low energy consumption. They include complete recycle of solvents and reagents, and no secondary waste production that requires disposal. Biowaste derived products are chemical intermediates and specialities. They must meet regulatory and performance's requirements for tailored consumers' uses. To this end, the ongoing R&D work is developing two steps and single step processes. The two steps' process consists in the hydrolysis reaction, followed by isolation, and oxidation or hydrogenation of SBO. In the single step process, hydrolysis and oxidation or hydrogenation are carried out at the same time, without SBO isolation in between hydrolysis and oxidation or hydrogenation. Products characterization is by NMR and IR spectroscopy, potentiometric titration, HPLC-MS, molecular weight determination, and C and N microanalyses.

At the time of the presentation, the available results for the SBO assisted fermentation, and for the AD and CP oxidation and hydrogenation processes will be reported.

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