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AN OVERVIEW OF CIRCULAR ECONOMY APPROACH FOR TEXTILE WASTE: PROCESS SUSTAINABILITY IN ETHANOL PRODUCTION

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Introduction

The textile industry is one of the most polluting industries having a significant impact on the aquatic environment. This is mainly due to the use of significant amounts of water for processing, resulting huge quantity of contaminated water. It is known that, to produce 1 kg of textile fibre a volume of about 200 L of water is required throughout the manufacturing process. The water resulting from the dyeing process contains toxic compounds that are difficult to biodegrade, such as dyes and toxic metals. To this end, the environmental impact must be reduced by introducing less polluting manufacturing technologies, which must be pursued in order to reduce waste produced in the textile industry. The studies reported 92 million tonnes (MT) of textile waste in each year worldwide, of which 6 MT is generated in the European Union, 17 MT in the USA and 20 MT in China. Moreover, in order to implement the context of the circular economy, there is a need by a closer collaboration between: manufacturing and recycling companies involved. New strategies for recycling and reuse of textile wastes need to be addressed by: (i) collecting them for reuse; (ii) converting them into virgin fibres for new textile materials; and (iii) producing ethanol from their processing. The aim of this paper was to present the economically and feasible environmental methods in order to convert textile waste into valuable compounds (e.g. ethanol and biogas).

Materials and methods

At present, in order to reduce the polluting impact of textile waste, the following methods of destruction and recycling are applied: (i) storage in specially designed areas; (ii) recycling methods applied for post-consumer waste in function of composition; (iii) burning by storing the energy obtained from the process, with the major advantage of reducing volume and obtaining energy. However, after burning process results significant quantities of hazardous organic and inorganic substances together with CO_2 production. Also, (iv) chemical and ecological treatments can be applied. Thus, one way to recover cellulose from textile waste can be achieved by treatment with NaOH, Na_2CO_3 or H_3PO_4. Cellulose powder can also be obtained using H_2SO_4 directly on the textile waste. Consequently, the disadvantage of alkaline/acid treatment is that significant quantities of leachate are produced being difficult to process. At the same time, the removal of synthetic dyes from the structure of textile fibres must be taken into account. For the chemical processes previously presented, another possibility to recover cellulose from textile waste is based on environmentally friendly extractants (e.g. N-methylmorpholine-N-oxide - NMMO). The basic concept of this process is to dissolve the cellulose from textile waste in the environmentally

friendly extractant and separate it from the non-cellulosic fibres. Thus NMMO dissolves cellulose, which in the presence of aqueous medium causes precipitation of cellulose which is recovered by filtration. The obtained cellulose is washed, followed by centrifugation to remove NMMO. Subsequently, cellulose extracted has undergoes enzymatic hydrolysis followed by fermentation to obtain ethanol or for anaerobic digestion to obtain biogas. In Figure 1 are presented experimental steps for obtained ethanol or biogas starting for textile waste (where textile waste represents blends of polyester/cotton and polyester/viscose).

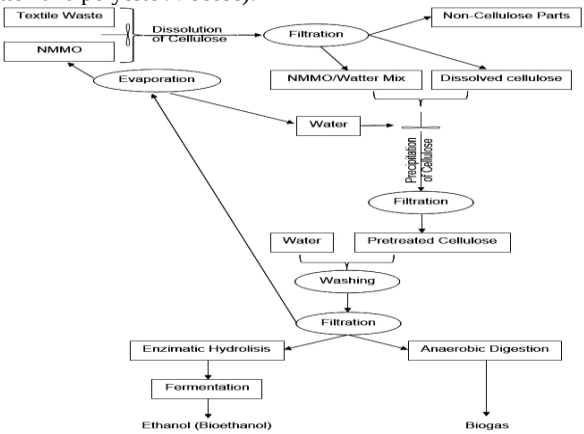

Fig. 1. Experimental procedure for obtaining ethanol using the environmentally friendly agent necessary for cellulose dissolution from recycled textile waste.

Results and conclusions

For the implementation ecological extraction of cellulose, firstly the selective collection system for textile waste, it is necessary. Herein, the main advantages of using the green agent for valorisation textile waste in order to extracting cellulose and converting it into ethanol and/or biogas are:

1. Separation of cellulosic and non-cellulosic fibres; thus, the resulting non-cellulosic polymers are easier to process than the basic waste.
2. Dissolved cellulose hydrolyses easily into sugars.
3. It is possible to recover and reuse the extracting, in a new hydrolysis process.
4. Cellulose dissolution takes place at ambient temperature and subsequent in ethanol.
5. The process is environmentally friendly, because for obtained by-products chemical agents are not involved.
6. Since the rapid extraction of cellulose is produced, the production costs for processing the waste and obtained the cellulose are reduced.
7. This process is feasible and can be integrated into existing ethanol and/or biogas plants.

To conclude, this paper briefly outlines methods for treating and recovering textile waste into valuable compounds. Thus, feasible methods (chemical and environmentally friendly) for the converting textile waste are presented. From the research carried out, it was found that the most appropriate method is the environmentally friendly one, because minimizes the negative impact of additional generation of new toxic waste.