TOWARDS A CIRCULAR ECONOMY IN TEXTILES: RESYNTEX AND THE EUROPEAN UNION

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Introduction

Europe is at crossroads in terms of growth and living standards. The nexus between circular economy, RESYNTEX and textile provides direction and opportunity for seamless prosperity. The current strategy consisting of a linear economy for resource utilization, a surprisingly wasteful model of value creation, is leading to decline in prosperity and concomitant global influence. It must develop a more resource savvy circular economy, with the biological and mineral nutrients of modern society continuously circulating. Rather than face a bleak and uncertain future dependent on resources from overseas, Europe needs to develop technologies towards self-sufficiency in energy and water and keep materials flowing required for consumption (Clark 2012). This will insure reduction in virgin resources and treat waste as a valuable input rather than a burden for welfare of society and the environment.
RESYNTEX, the European Union's Horizon 2020 research and innovation funded program, will produce secondary raw materials from blends and pure components of unwearable textile waste with a strong circular economy focus. The project will develop and demonstrate a strategic design for closed loop textile recycling throughout the value chain. The technology associated for recovery of the basic monomer constituents from one major component, polyester, will be discussed.

Environmental Economics

In today's economy, natural resources are mined, turned into products and finally discarded. While the recycling of waste and strategies of efficient extraction of raw materials reduce consumption, this remains fundamentally an open, linear system which places unsustainable demands on the environment as a waste reservoir. Furthermore, major challenges on society thru Linear Economy impose constraints on global development thru the following: Population growth, carbon footprint, energy consumption, resource (mineral & natural) utilization, and water shortage indicated in Figure 1(Reh 2013).

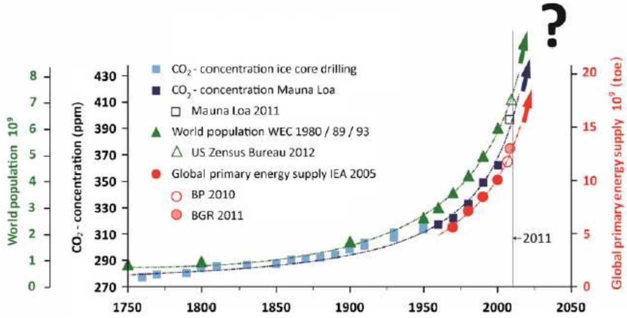


Figure 1. Global Developments

The concept of Circular Economy, first raised by Pearce and Turner (1990) closes the resource loop thereby capturing and reusing large volumes of finite resources. Structural changes in the industrial systems will be involved, to be sure, for the new concept to be restorative and regenerative by design and aspire to keep products, components (energy and water) and materials at their maximum efficiency and productivity, and distinguishing between technical and biological cycles. An idealized Circular Economy concept is shown in Figure 2. A number of global consulting companies, most notably McKinsey and Accenture have suggested a variety of business models to extract value and remain financially viable. Some of these models are: Circular supplies (circular production and consumption system), Resource recovery (minimize material leakage), Product life extension (remaking products), Sharing platforms for collaboration, and Product as a service (pay for use).

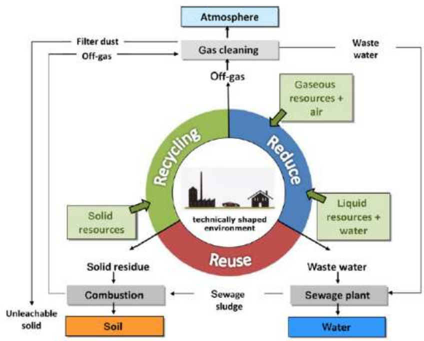


Figure 2. Circular Economy Concept

RESYNTEX

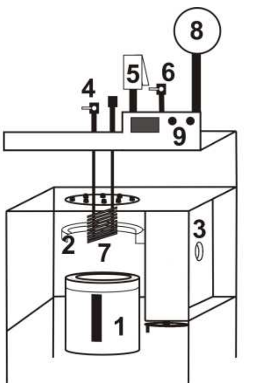
The RESYNTEX project aims at designing, developing and demonstrating industrial symbiosis between textile waste and the chemical industry. This is based on the chemical/enzymatic transformation of textile waste in a form that facilitates easy acceptance as feedstock by the chemical industry in order to produce high value added at competitive production costs. The project will consider and demonstrate the viability of complete value chain beginning with the citizen behaviour change and the textile collection of unwearable textiles demonstrating the production of the transformed textile into chemical feedstock. Interdisciplinary information exchange between various industrial and societal sectors (symbiosis) involved is vital for successful project performance.

Textiles

The project will consider recovery of monomers/constituents from both natural and man-made fibers in pure or blended form obtained from post-consumer and/or post-industrial waste. The emphasis in this paper is on the largest fiber in production globally – polyester.

Experimental

A Design of Experiment was employed to determine the kinetics and thermodynamics of neutral hydrolysis of polyester for recovery of monomers. The hydrolytic depolymerisation of PET was conducted under autogenous pressure in a pilot reactor (Figure 3). A two level variable design considered temperature of reaction, PET/water ratio, initial molecular weight of polymer, and amount of catalyst used.



1. Stainless steel vessel
2. Metallic holder
3. Main switch
4. Water management valve for water circulation
5. Pressure relief valve
6. Ventilation valve
7. Cooling coil
8. Pressure gauge
9. Control panel with heater switch

Figure 3. High-pressure reactor for neutral hydrolysis of PET

Results & Discussion

The experiments conducted in four phases consisted of two types of polymers (virgin and recycled) each with and without catalyst to enhance depolymerization. The charge ratio of water to PET was varied from 4 to 10 to include both irreversible and reversible conditions. The range of temperature was 180 to 250 °C. The reaction proceeded during temperature increase after charging from room temperature to designated reaction temperature. The reaction rate of PET hydrolysis was fast at 250 °C. At this temperature and high charge ratio, the product converted to powder form consisting mostly of terephthalic acid.

Conclusions

The depolymerization reaction of PET in presence of water at high temperature is obtained by measuring the carboxyl end group concentration. The rate of appearance of [COOH] results in autocatalytic mechanism with the reaction rate of 0.5 order with respect to carboxyl end group concentration. The equilibrium constant is obtained at high charge ratio of water to PET. The thermodynamic parameters of Gibbs free energy, enthalpy and entropy of reaction were obtained using van’t Hoff equation.

Keywords: Circular Economy, RESYNTEX, Textiles, Kinetics, Recycling

References

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