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Recycling of vat and reactive dyed textile waste to new colored man-made cellulose fibers

Haslinger, S., Wang, Y., Rissanen, M., Lossa, M.B., Tanttu, M., Ilen, E., Määttänen, M., Harlin, A., Hummel, M. and Sixta, H. 2019. Recycling of vat and reactive dyed textile waste to new colored man-made cellulose fibers. *Green Chemistry, 21*(20), 5598-5610

The successful recycling of colored textile waste and reuse of respective dyes would represent a major milestone of global efforts to reduce the environmental impact of the textile industry. The chemical upcycling of dyed pre- and postconsumer cotton waste is promoted by studying the spinability and color fastness of seven vat and reactive dyes (i.e. Indanthren Blue BC 3%, Indanthren Red FBB coll, Indanthren Brilliant Green FBB coll, Levafix Brilliant Red E-4BA, Levafix Blue E-GRN gran, Remazol Brilliant Blue R spec, and Remazol Black B 133%) during dry-jet wet spinning. Apart from the fabrics dyed with Levafix Brilliant Red E-4BA, all samples dissolved in 1,5-diazabicyclo[4.3.0]non-5-ene actetate, a superbase based ionic liquid, and could be converted to new colored man-made cellulose fibers. It was found that there is a clear discrepancy between the recyclability of dyed pre- and postconsumer cotton waste, resulting in significantly higher fiber properties up to tenacities of 59.8 cN/tex and elongations of 13.1% in case of the latter. All recycled fibers displayed a noticeable color change in the CIELab space (ΔE = 8.8–25.6) throughout the spinning process. Despite these deviations, almost all fibers and demo fabrics produced thereof exhibited bright colors that can be reused in textile industry. Only Remazol Black B 133% did not sufficiently translate to the new textile product. The wash and rubbing fastness of the fabrics knitted from the regenerated fibers was superior to the dyed waste fabrics mainly because of the homogenous distribution of the dyes along the fiber cross-section.

Model of industrial textile waste management

Rapsikevičienė, J., Gurauskienė, I., Jučienė, A. 2019. Model of industrial textile waste management, Environmental Research, *Engineering and Management, 75*(1), 43-55

Manufacturing of textile and apparel contributes depletion of water resources, the use of natural resources, the release of water and air pollution and increasing the amount of waste

entering landfills. Industrial textile waste represents nearly half of the whole flow of textile waste. Major part of the industrial textile waste is landfilled, because of the lack of technologies and infrastructure for recycling. The practice of mixing all the textile cuttings at the apparel production companies, leads to the challenge for reuse or recycling of the leftovers.. Textile companies are obliged to look for alternative waste management options in order to meet the requirements and challenges of Circular Economy action plan published by the European Commission. This article represents the model created for the analysis of industrial textile waste flows and development of scenarios for reasonable waste management. The model and methodologies involved are oriented to preventive solutions – The evaluation of the efficiency of the model is based on sustainability indicators which represents the effect of the scenarios for environmental, economic and social aspects. The implementation of the model to the case study of Lithuanian apparel production company, have disclosed that improvements at the industrial textile waste management within the company, could lead to the increase of efficient use of resources (three times) and environmental impact (twice).

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Review of wool recycling and reuse

Russell, S., Ireland, A. 2016. Review of wool recycling and reuse, *RILEM Bookseries, 12*, 415-428

The clothing and textile industry forms a considerable part of the world's economy. Of the more than $1 trillion sales of clothing worldwide, roughly two thirds is consumed in Western Europe and North America (University of Cambridge 2007). In addition to high-street products purchased directly by consumers, clothing is also consumed in the form of workwear, uniforms and corporate apparel distributed by brand owners and employers. Once this clothing is discarded by its user the main End of Life (EoL) options are in descending order of resource efficiency: (a) Reuse—garments worn again after donation and/or re-sale; (b) Closed loop recycling—garments used as raw materials for the manufacture of new products of similar value; (c) Open loop recycling—garments used as raw materials to manufacture industrial products of lower value; (d) Incineration—thermal energy generation; (e) Landfill. This chapter focuses on the collection, recycling and reuse of wool garments with particular emphasis on mechanical recycling in open and closed loop systems.

Apparel disposal and reuse

Lewis, T. 2015. Apparel disposal and reuse, *Sustainable Apparel: Production, Processing and Recycling*, 233-250

The fate of clothing at the end of its life cycle has become increasingly burdensome and complicated with the growth of mass production and multinational retail firms enabling the rapid delivery of fashionable items on a global scale to a trend-driven industry. The imbalance of consumption and disposal often pushes the overconsumption of developed nations into the markets of lesser-developed countries. To understand the context of apparel reuse and disposal, an examination of the global supply chain for apparel production and consumption is necessary because apparel is discarded at different points along this chain. Charitable organizations such as Oxfam, Goodwill, and the Salvation Army may be the first point of collection for unwanted clothing, but other for-profit organizations have entered the market for clothing collection in an effort to meet the market demands of a global trade in used clothing. Once the used garments enter a new market with new consumers it cannot be assumed that this is a sustainable solution to end-of-life management. Consideration of the impact of the used garment once it passes on to a new market should be factored into part of its life cycle. Demand for used clothing is slowing in some developing nations due to low-cost imports of new clothing or import restrictions. Therefore, developed nations will have to generate more alternatives for reuse in their own countries in order to prevent direct disposal of used clothing into waste streams.

Sustainable waste management strategies in the fashion industry sector

Dissanayake, G., Sinha, P. 2013. Sustainable waste management strategies in the fashion industry sector, *International Journal of Environmental Sustainability, 8*(1), 77-90

Textile waste can be either pre-consumer or post-consumer. In recent years, postconsumer textile waste has gained increased attention, both within the industry and academia, due to environmental concerns. The emergence of fast fashion culture and the throwaway attitude of consumers build up mountains of unwanted fashion clothing disposed of in landfill sites. This paper analyses recycling, reusing and refashioning as three alternative strategies for waste management in the fashion industry sector. Based on empirical data collected by using a multiple case study approach, the paper discusses the concept of each strategy, and associated sustainability impacts of employing each strategy in practical terms. Suggestions are provided on the development of waste diversion programs and sustainable business models for the developing economies.

Reuse and recycling of textile solid wastes

Adivarekar, R.V., Pisal, S. 2009. Reuse and recycling of textile solid wastes, *Journal of the Textile Association, 70*(3), 118-126

Due to increased awareness and strict laws, disposal of waste is strictly avoided through the use of recycling technologies. The most practical way to reduce pollution is to reuse and recycle the waste several times before it is discarded. Though textiles are nearly 100% recyclable, in reality, the rate of recycling in textiles, both preconsumer and postconsumer is not very high. This paper sheds light on the recycling industry, on the scope of recycling the textile solid waste through various mechanical and chemical processes and also recycling from an energy saving perspective. The importance of the recycling behavior through the micro and macro approach is also emphasized.

Recycling of waste PET into useful textile auxiliaries

Shukla, S.R., Harad, A.M., Jawale, L.S. 2008. *Recycling of waste PET into useful textile auxiliaries, Waste Management, 28*(1), 51-56

Polyethylene terephthalate (PET) waste fibers were initially depolymerized using a glycolysis route in the presence of sodium sulfate as a catalyst, which is a commonly used chemical

and ecofriendly as compared to heavy metal catalysts. Good yield of the pure monomer bis(2-hydroxyethylene terephthalate) (BHET) was obtained. Further, to attempt its reuse, the purified BHET was converted to different fatty amide derivatives to obtain quaternary ammonium compounds that have a potential for use as softener in the textile finishing process. The products were characterized by infrared spectroscopy. Application of these synthesized compounds was carried out on cotton fabric; they were evaluated for performance and were found to give good results. The chemicals used during depolymerization and reuse of PET are inexpensive and comparatively less harmful to the environment, and thus offer advantages in the chemical recycling of polyester waste fibers.

Carpet recycling: Determining the reverse production system design

Realff, M.J., Ammons, J.C., Newton, D. 1999. Carpet recycling: Determining the reverse production system design, *Polymer-Plastics Technology and Engineering, 38*(3), 547-567

Roughly 4 billion pounds of carpet are disposed of in the United States each year. This carpet is composed of a significant fraction of nylon, polypropylene, and polyester fiber. A key limiting factor to recycling is effective design and development of the reverse production system to collect and reprocess this large volume of valuable material. A reverse production system is composed of material and chemical recycling functional elements interconnected by transportation steps. In this article, we develop a mixed-integer programming model to support decision-making in reverse production system design. To illustrate its use and applicability, we apply the model to a representative U.S. carpet recycling industrial case study. The overall economic feasibility of recycling is strongly dependent on the volumes that can be expected from investments in collection infrastructure. The geographic location of processing centers influences the network economics, and the subdivision of recycling tasks to avoid the shipment of low value material is proposed as an effective strategy for carpet recycling.
