PHD PROJECT DESCRIPTION
(4000 characters max., including the aims and work plan to de published online)

Project title: Chemical Recycling of Fast-Fashion Waste

1.1. Project goals

The aim of the project is to develop sustainable chemical methods for the recycling of fast-fashion textile waste and treatment of contaminated textile wastewater. The project will focus on selective depolymerization of polymeric textile materials, recovery of valuable chemical feedstocks, and removal of hazardous dyes and organic pollutants from water streams using adsorbents obtained from textile waste.
A particular emphasis will be placed on understanding interfacial physicochemical phenomena occurring during recycling and purification processes, including:

- adsorption and transport of pollutants,
- catalytic degradation of textile-derived compounds,
- interactions at solid–liquid interfaces,
- structure and reactivity of interfacial water.

1.2. Outline

The fast-fashion industry is one of the largest sources of textile waste and water pollution worldwide. Large quantities of mixed polymeric textiles, dyes, surfactants, and microplastic contaminants are generated during textile production and disposal. Current recycling technologies are limited by poor selectivity, high energy demand, and difficulties associated with mixed-material waste streams.
This PhD project aims to investigate chemical recycling pathways for textile waste, including hydrolysis, glycolysis, and catalytic depolymerization of polyester-based materials. Simultaneously, the project will explore methods for the removal and degradation of textile-derived pollutants from wastewater using advanced adsorbent and catalytic materials.
The project will involve:

- synthesis and characterization of functional materials,
- adsorption and catalytic studies,
- spectroscopic monitoring of chemical transformations,
- investigation of water-mediated interfacial processes,
- evaluation of environmental and technological applicability.

Special attention will be devoted to operando and in situ spectroscopic methods allowing real-time observation of processes occurring during chemical recycling and pollutant removal.

1.3. Work plan

A. Characterization of fast-fashion waste

- identification of textile components,
- analysis of dyes and additives,
- physicochemical characterization of waste materials.

B. Chemical recycling of textile polymers

- carbonization, dehydration, hydrolysis and glycolysis of polyester-based textiles,
- catalytic depolymerization studies,
- optimization of reaction conditions,
- recovery and analysis of depolymerization products.

C. Wastewater purification and dye removal

- adsorption studies of textile dyes,
- catalytic degradation of organic pollutants,
- evaluation of advanced oxidation approaches,
- development of functional adsorbent materials.

D. Interfacial and operando studies

- investigation of water–surface interactions,
- adsorption thermodynamics and kinetics,
- operando FTIR monitoring,
- analysis of catalytic and adsorption mechanisms.

E. Circular materials and environmental integration

- conversion of textile waste into functional carbon materials,
- development of adsorbents for wastewater purification,
- evaluation of reuse and circularity concepts,
- integration of recycling and water-treatment approaches,
- environmental assessment of developed technologies.

1.4. Literature (max. 7 listed as a suggestion for a PhD candidate preliminary study)

Wiśniewski, et al. Small 2026, 22(12), 2412754

Green Chemistry, recent articles

Environmental Science & Technology, recent articles

Geyer, R.; Jambeck, J. R.; Law, K. L. Production, use, and fate of all plastics ever made. Science Advances 2017, 3, e1700782.

1.5. Required initial knowledge and skills of the PhD candidate

Preferred background:

- chemistry,
- materials science,
- chemical engineering,
- environmental engineering,

- biotechnology or related disciplines.

Experience in spectroscopy, catalysis, materials synthesis, or environmental chemistry will be an advantage but is not mandatory.

1.6. Expected development of the PhD candidate's knowledge and skills

chemical recycling technologies,

environmental and sustainable chemistry,

adsorption and catalytic processes,

advanced spectroscopic techniques,

operando/in situ characterization methods,

materials synthesis and characterization,

scientific data analysis,

preparation of scientific publications and conference presentations.

The project is expected to provide strong preparation for future scientific or industrial careers related to sustainable materials, recycling technologies, environmental protection, and green chemistry.