

Student:	Name:	
	Student ID:	Departement:
	University: EPFL	
Thesis:	Title: Biodegradable wire for DC rotary motors in transient drones	
	Kind of Thesis:	Semester: SS or FS 2026
Supervisor:	Prof. Dr. Mirko Kovac	
Advisor:	Dr. Kyung-Sub Kim	
Co-Advisor:		

Start of the Project:	01.03.2026
Deadline delivery final report:	31.08.2026

Introduction

According to a UN report, global electronic waste reached 62 million tons in 2022 alone, and 80% of it is not recycled, leading to severe soil and marine pollution. [1] With the recent remarkable advances in robotics, the deployment of robots is increasing at a pace comparable to that of electronic devices, and the risk of robotic waste becoming a serious environmental issue in the near future is steadily growing.

To address this problem, transient robotics composed of biodegradable materials has attracted increasing attention, offering potential applications in various fields such as medical robotics, environmental exploration, and agriculture. [2] Exploratory robots can swim in the deep sea, crawl through soil, or fly into dense forests, and after completing their missions, they can decompose into non-toxic byproducts in the natural environment. Such scenarios, where materials and operating environments are precisely matched to maximize sustainability, make exploration one of the most promising application areas for transient robotics.

Recently, a microfibrillated cellulose/gelatin-based transient drone demonstrated for the first time the feasibility of short-term, large-area natural environment monitoring. [3] However, in order to achieve fully biodegradable transient drones, the development of a biodegradable DC motor remains a missing piece. One of the key components of a motor, the electromagnetic coil, requires a biodegradable conductive wire. This can be realized by coating dissolvable metal wires such as Mo or W with biodegradable polymers, but it requires careful engineering considerations, including the selection of thermally stable biodegradable polymers, polymer processing methods, viscosity control through filler loading, and winding speed control.

This project focuses on forming a thermally stable microscale coating layer on biodegradable wires, and can be followed by further studies such as electromagnet performance evaluation and motor design.

Objectives

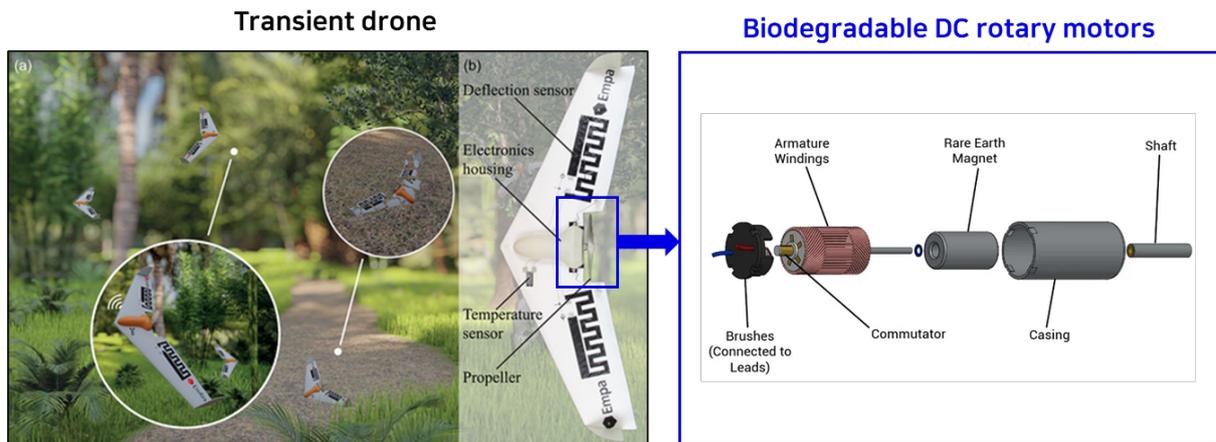


Figure 1. Overview of the transient drone scenario (left) [3] and the expected deployment diagram of the biodegradable DC motor (right).

The ultimate goal is to develop a transient drone in which all components, including the rotary motor, naturally degrade into non-toxic byproducts, thereby minimizing environmental impact (Fig.1). As part of the preliminary stages toward realizing the final device, **this project aims primarily to achieve biodegradable wire insulation with high thermal stability.** Depending on the progress of the project, subsequent work may include the development of a soil-based degradation evaluation platform for biodegradable wires, characterization of biodegradable electromagnets, optimization of motor design, and the development of motor-drone integration processes. The work packages are listed below.

Work breakdown

The work will be subdivided in the following tasks:

Surveying of literature:

The student will initially study the structure of DC motors and their characteristics. Subsequently, the student will study the types of biodegradable materials for wire insulation, as well as their thermal and mechanical properties. Finally, the student will study the internationally standardized platforms for polymer biodegradation evaluation.

Fabrication:

The student will develop and optimize biodegradable wire coating technology (Fig. 2).

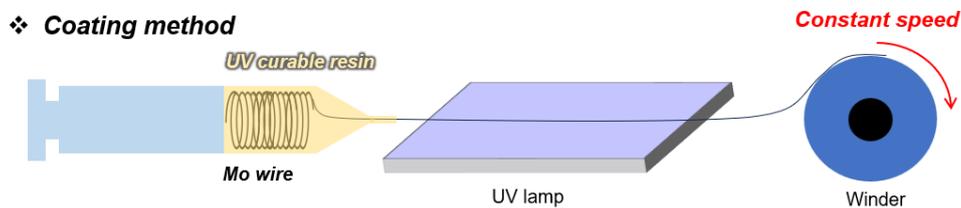


Figure 2. Schematic of the wire coating method. This is an example of one possible approach and may be modified depending on the research direction.

Characterization:

The student will evaluate the quality of the coating using OM or SEM images.

The student will characterize the electromagnetic properties and thermal lifetime of the wire, which vary depending on the metal wire diameter, coating thickness, and the number of coil turns.

The student will optimize the appropriate wire size and design for biodegradable motors.

The student will assess the biodegradability of the biodegradable wires under composting and/or aqueous conditions according to international standards (Fig. 3).

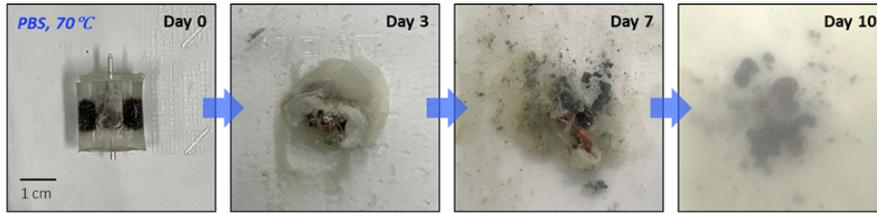


Figure 3. The partial biodegradation of a rotary motor prototype with non-degradable copper wires. The goal of this project is to replicate this experiment with a fully biodegradable motor device.

Integration:

The student will fabricate a biodegradable motor by combining biodegradable wires with other biodegradable components, including magnets, casing, brushes, and shaft.

The work location will be the Laboratory of Sustainability Robotics at EPFL (Lausanne) and will be conducted in collaboration with Empa (Dübendorf, Zurich). The formal supervision will be performed by Prof. Mirko Kovac. The project starting day would be discussed with Kyung-Sub Kim.

Requirements

The student belongs to EPFL ENAC or STI.

The student is motivated to work on an interdisciplinary research topic encompassing material/electrical/environmental/mechanical science & engineering.

Bibliography

- [1] ITU & UNITAR, Global E-waste Monitor 2024, Geneva/Bonn
- [2] F. Hartmann, M. Baumgartner, M. Kaltenbrunner, Becoming Sustainable, The New Frontier in Soft Robotics. *Adv. Mater.* **2021**, 33, 2004413.
- [3] F. Wiesemüller, S. Meyer, Y. Hu, D. Bachmann, A. Parrilli, G. Nyström, and M. Kovač, Biopolymer Cryogels for Transient Ecology-Drones. *Adv. Intell. Syst.* **2023**, 5: 2300037.

Lausanne, 29/01/2026

Supervisor:

Prof. Mirko Kovac,
EPFL ENAC LSR

Advisor:

Dr. Kyung-Sub Kim,
EPFL ENAC LSR

Co-Advisor:

Student:
