

Particle-based sensor materials enable plant-inspired upconverting I-Seeds as flying environmental sensors

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Environmental parameters are a critical basis for decision-making in precision agriculture, remediation, and emergency management. State of the art probes for remote read-out require electronics based on complex materials that produce e-waste.¹ Here, we discuss self-deployable, biocompatible, flying I-Seeds as alternative probes. The bioinspired seeds are designed to provide optical sensor signal to be read using drones equipped with fluorescence light detection and ranging (fLIDAR) technology.

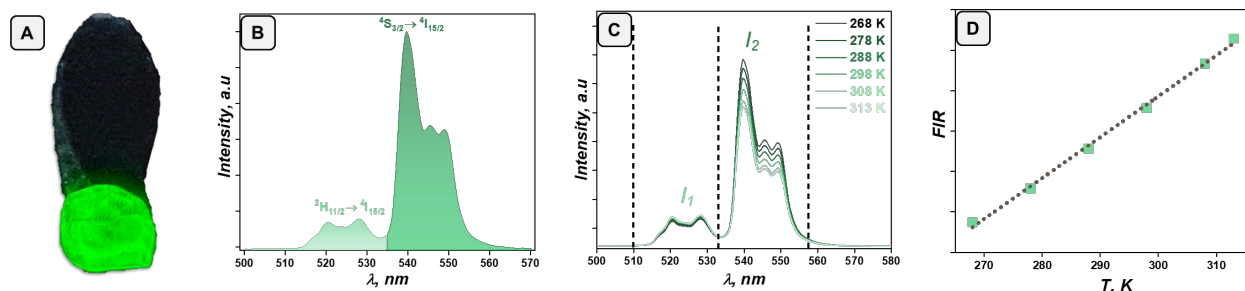


Figure 1: Environmental sensors with ratiometric read-out.⁴ (A) I-Seeds were 3D-printed from sensor materials that provide (B) upconverting photoluminescence. (C) Ratiometric analysis of the optical emission enables the reconstruction of environmental parameters, e.g. (D) temperature.

We make I-Seeds from “sensor materials” with upconverting, plasmonic, and fluorescent nanoparticles that are embedded in a permeable polymer matrix. The particles are electromagnetically coupled and arranged such that some of them react to environmental conditions or analytes. Others provide reference signals for ratiometric read-out.² For example, Hg^0 is detected based on its absorption by gold that causes a plasmonic shift and alters the emission of an upconverting lanthanide-doped particle.³

The I-Seeds are designed based on shapes of natural seeds.⁴ They are lightweight and carried passively by the wind and dispersed over large distances and areas. We 3D-printed artificial models to emulate the morphometric and aerodynamic characteristics of the natural seeds. Biodegradable polymers (polylactic acid (PLA) and cellulose) are used as matrices to reduce environmental impact.

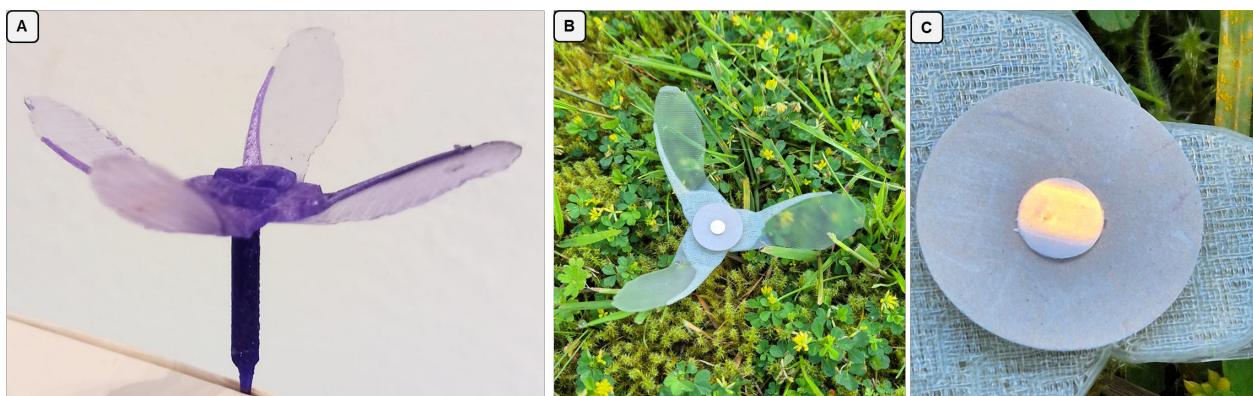


Figure 2: A mercury-sensing I-Seed. (A) The shape was designed to optimize dispersion properties and (B) enable upright landing. (C) The sensor patch detects Hg^0 concentration and can be read from a drone.

We will show I-Seed with upconverting lanthanide doped particles that emit in the red, green and blue (RGB) wavelengths when excited with near infrared (NIR) lasers. The intensity of their fluorescence bands depends on temperature, humidity, CO_2 or Hg^0 concentration. Ratios of different emission bands (in the R, G or B regions) are used to provide robust values for environmental monitoring.

References

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