

Popular science summary

Chronic Obstructive Pulmonary Disease (COPD) is a serious lung disease that makes it hard to breathe and affects millions of people around the world. Even though there are inhaled medications available, current treatments often fail to deliver the medicine deep into the lungs where it is really needed. Many medications either do not reach the lungs well or get stuck in the thick mucus that builds up in COPD patients. This project **aims to improve how we deliver these medicines by creating a smarter system inspired by nature.**

Our goal is to **develop a new inhalable treatment that effectively delivers medication deep into the lungs and keeps it there long enough to work.** We are combining two innovative technologies to achieve this:

1. **Pollen-like Microparticles (PMs):** These tiny particles are designed to mimic pollen grains, which are naturally great at traveling through the air. They will help ensure the medicine goes deep into the lungs, tackling the problem of inhaled drugs not landing where they should.
2. **Lipid Nanoparticles (LNPs):** These super tiny fat-based particles act like little delivery vehicles that protect the medication and help it break through the thick mucus in COPD patients' lungs.

By combining these two technologies, we create a **two-step delivery system.** The PMs will carry the LNPs deep into the lungs, and then the LNPs will slowly release the medication where it can be absorbed effectively.

Current inhalers and nebulizers are not doing the job well. A lot of the medicine gets wasted because it does not reach the lungs properly. Even when it does, much of it can get stuck in mucus and be cleared out too soon to work. **Our system addresses these issues by:**

- ✓ helping more medicine reach the deep parts of the lungs using pollen-inspired microparticles;
- ✓ assisting the drug in breaking through mucus barriers with lipid nanoparticles;
- ✓ gradually releasing the drug for longer-lasting effects;
- ✓ reducing side effects by keeping the medication focused in the lungs instead of spreading through the body.

The drug we are focusing on is **ensifentrine**, which is a **promising new treatment for COPD** that opens airways and reduces inflammation. However, right now, it needs to be inhaled frequently and is not very efficient. **Our delivery system could make it more effective, longer-lasting, and easier to use.** To make this idea a reality, we will:

- ✓ Design and test the pollen-like microparticles to find the best size and shape for reaching the lungs effectively.
- ✓ Pack ensifentrine into lipid nanoparticles to ensure it gets to the right cells.
- ✓ Test the system in advanced lung models and animal studies to confirm it works well and is safe.

If this project is successful, **it could change COPD treatment, giving patients a more effective and easier therapy.** This nature-inspired technology **could also lead to better treatments for other breathing problems** like asthma, lung infections, and more.