Medicine Dissolution in a Microgravity Environment Emulated by Acoustic Levitation

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As humanity ventures beyond Earth, the challenges of space travel extend beyond rocket science and astrophysics. Astronauts face extreme physiological stress, and during deep-space missions where medical resources are limited, reliable drug performance becomes critical. However, microgravity can alter how medications dissolve, potentially affecting their effectiveness. This project investigates medication dissolution in microgravity using an acoustic levitator. Medicine and water were placed at the acoustic node for controlled time intervals to measure dissolution rates. Because retained moisture made direct weighing unreliable, differential weighing was used, with controlled microwave heating to evaporate the remaining water before determining final mass. The methodology was validated through ground trials, producing dissolution rates consistent with pharmaceutical literature. Experimental results showed that microgravity significantly altered dissolution behavior. Using the Noyes-Whitney equation to model these effects, Ibuprofen's dissolution rate decreased by 50%, while Aspirin's rate decreased by 29%. A Physics-Informed Neural Network (PINN) was developed to model dissolution behavior by incorporating the governing physics of the Noyes-Whitney equation into the learning process of the loss function, ensuring that predictions remain physically consistent. The model was trained on experimental Earth-based data and predicted dissolution behavior under microgravity conditions with 95% accuracy, reducing the need for extensive experiments where direct testing opportunities are limited. This research provides a foundation for space-optimized pharmaceuticals, supporting reliable drug delivery during long-duration space missions.

Awards Won:

Third Award of $1,200