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Microfluidic features integrated into devices compatible with traditional laboratory equipment.

Stanford researchers have developed an approach to seamlessly integrate microfluidic features into existing laboratory equipment, specifically designing a reaction tube compatible with standard thermal cyclers, enabling functionalities such as sample handling, molecular transport control, extraction, purification, mixing, and fluorescence detection for enzymatic reactions.

Microfluidic systems offer advantages over traditional methods of handling fluid samples such as analyzing lower volumes; control or avoiding mixing; and efficient heat transfer; . However, microfluidic devices typically require specially designed systems to interface with other lab equipment. Stanford researchers have designed a new paradigm to integrate microfluidic features into form factors which are directly compatible with existing laboratory equipment including PCR tubes in thermocyclers. They have designed a 3D reaction tube insert device which can be combined with a PCR reaction tube to enable functionalities including sample handling, electric field control of molecular transport, isotachophoresis extraction, purification, prefocusing; electromigration-based mixing; and buoyancy-based mixing. The current design is 3D printed but the method and shape are compatible with mass manufacturing methods. The assembly (PCR tube and microfluidic insert) is directly compatible with a thermal cycler system temperature control, and highly sensitive fluorescence detection.

Stage of Development - Prototype
Successful 3D-printed prototype. Demonstrated sample extraction (DNA purification from plasma), mixing, and compatibility with standard PCR protocols and readout.

Applications

- Laboratory equipment
- Precise control over enzymatic reactions

Advantages

- First microfluidic device structure integrated into a PCR tube
- Leverages existing infrastructure
- Compatible with existing laboratory equipment
- Temperature control
- Reduced ross- contamination risk
- Highly automated and integrated sample processing
- Potential for increased throughput
- Potential to achieve in a cost-effective format

Publications

- Jiang, Q., Zang, X., Wang, Y., Avaro, A. S., Huyke, D. A., & Santiago, J. G. (2025). A three-dimensional microfluidic device embedded within a thermal cycler tube for electrokinetic DNA extraction. *Lab on a Chip.*

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