[Inv8]

LabTube - a novel centrifugal microfluidic lab-on-a-chip platform for operation in standard laboratory centrifuges

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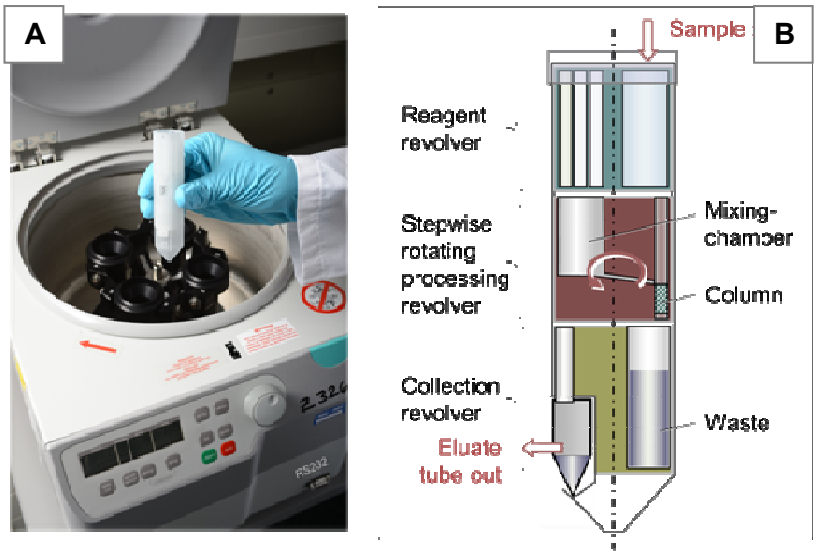
Microfluidic lab-on-a-chip platforms offer the perspective of miniaturized, automated and integrated liquid handling. As a major drawback, however, the vast majority of lab-on-a-chip systems require highly specialized processing instruments, posing significant investment costs to the user. We propose an ENTIRELY NOVEL LAB-ON-A-CHIP PLATFORM, the LabTube, which uses a STANDARD LABORATORY CENTRIFUGE AS PROCESSING DEVICE (Fig.1A).

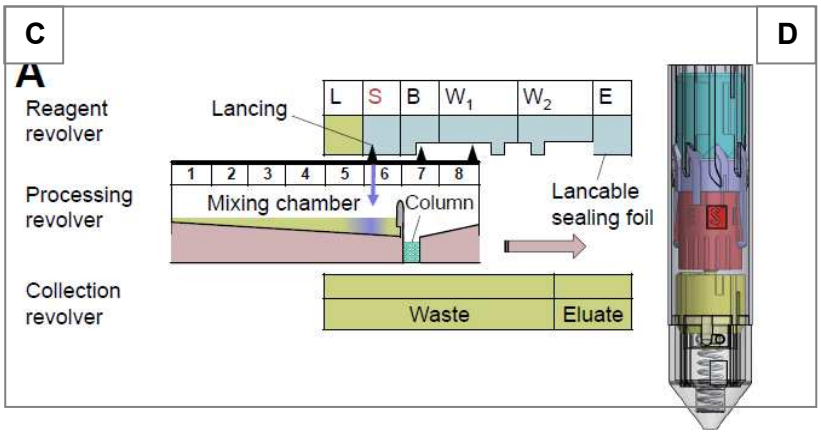
The LabTube cartridge consists of a 50 mL centrifuge tube that harbours three revolvers (Fig.1A&B). The upper revolver is used for sample loading and to prestore reagents required to perform a specific assay. The middle revolver is used for processing the assay and can be equipped with a mixing chamber and a solid phase extraction matrix (e.g. a column). AS KEY INNOVATION, THIS PROCESSING REVOLVER IS ROTATED STEPWISE BY A BALLPEN MECHANISM AND PIERCES THE PRESTORAGE CAVITIES OF THE REAGENT REVOLVER FOR A STEPWISE RELEASE OF SAMPLE AND REAGENTS (Fig.1C&D). The ballpen mechanism is actuated by changing centrifugal acceleration levels from above to below 300 g. The bottom revolver collects different fractions of processed reagents and can contain further reagents, e.g. to perform enzymatic detection reactions. Detachable tubes allow convenient removal of fractions to perform further downstream analysis, e.g. nucleic acid amplification and optical detection (Fig.1B).

LabTube prototypes have been used to demonstrate automation of multistep protocols, such as NUCLEIC ACID EXTRACTION (Fig.1E) or PROTEIN PURIFICATION (Fig.1F), decreasing the hands-on-time from >6 minutes to 1 minute per extraction with similar yields than in manually pipetted reference runs. Future applications of the LabTube will include point-of-care SAMPLE-TO-ANSWER NUCLEIC ACID TESTING with readout by standard laboratory instruments. The LabTube approach is intended to LOWER THE MARKET ENTRY BARRIER FOR LAB-CHIPS as the user only requires to purchase the disposable LabTube without the need to invest in any expensive highly specialized processing device.

References:

Journal papers under revision (to be updated)


A
B
Sample
Reagent revolver
Stepwise rotating processing revolver
Collection revolver
Eluate tube out
Mixing-chamber
Column
Waste


C
D
A
Reagent revolver
Processing revolver
Collection revolver
Lancing
L S B W1 W2 E
1 2 3 4 5 6 7 8
Mixing chamber
Column
Lancable sealing foil
Waste
Eluate

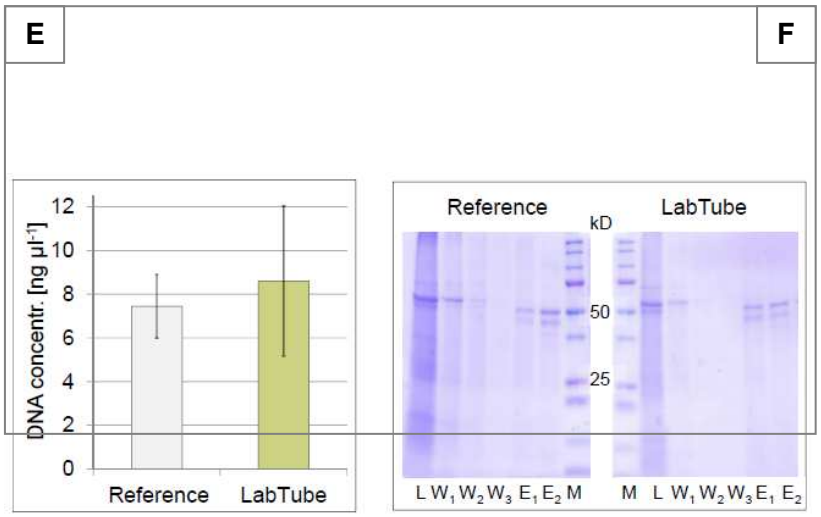

E
F
DNA concentr. [ng µl-1]
12
10
8
6
4
2
0
Reference
LabTube
Reference
LabTube
kD
50
25
L W1 W2 W3 E1 E2 M
M L W1 W2 W3 E1 E2

Figure 1. LabTube. (A) Insertion of LabTube into laboratory centrifuge. (B) LabTube design for nucleic acid extraction based on three revolvers for liquid handling. (C) Rolled up illustration of LabTube. (D) CAD view of ballpen mechanism for stepwise rotation of processing revolver. (E) DNA extraction from rape seed lysate, LabTube vs. manually processed reference. (F) Purification of His-Tag protein from cell lysate, LabTube versus manually processed reference.

Keywords: Centrifugal microfluidic platform, Ballpen mechanism, Lab automation, Nucleic acid extraction