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Simultaneous Targeted Isolation and Controlled release of Circulating Tumor Cells (CTCs) using a photothermal scaffold-embedded microfluidics system

[1]Nutan Shukla, [2]Ratnesh Das, [1]Elizaveta Mukhanova, [1]Alexander Soldatov

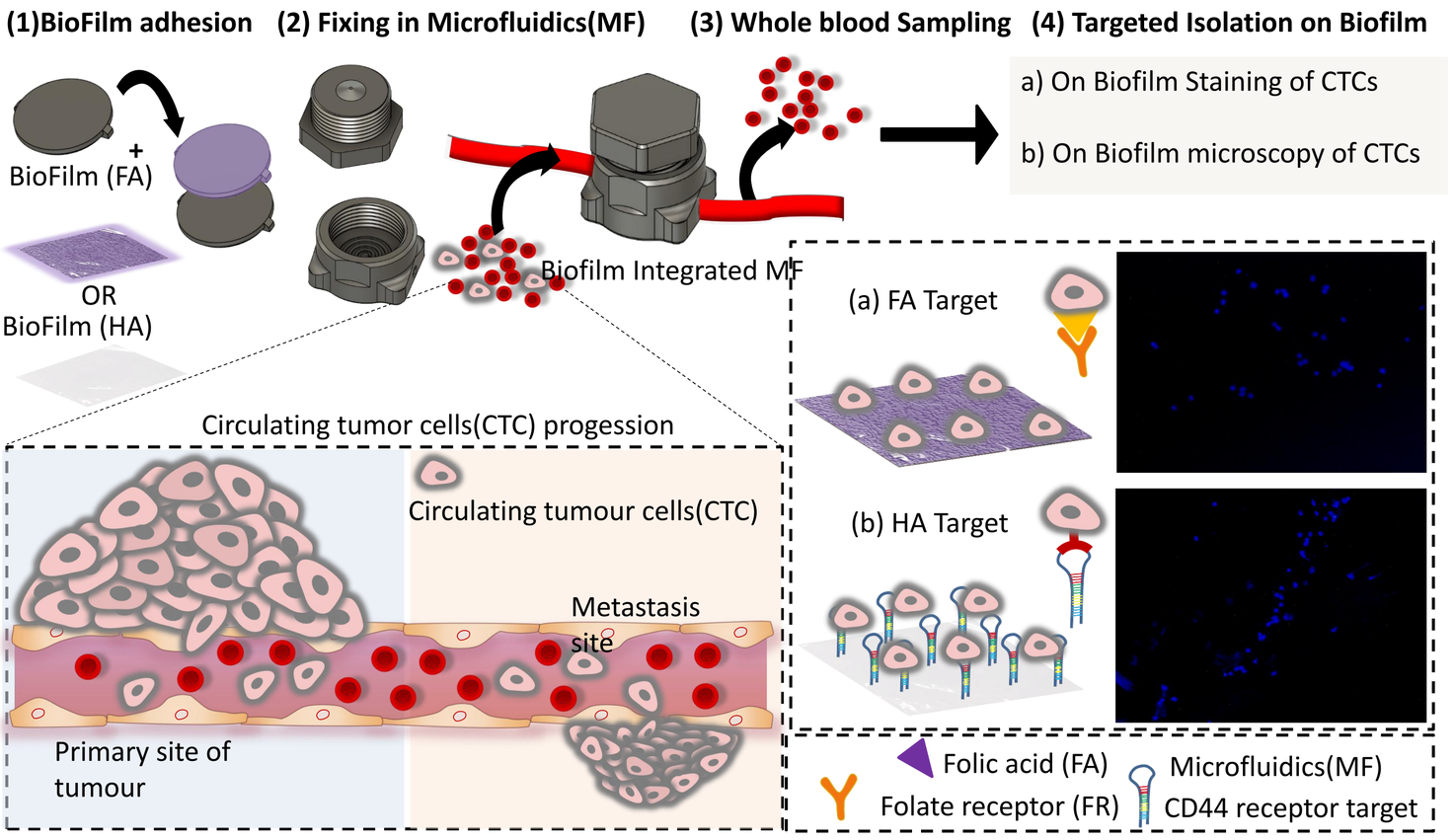
1. The Smart Materials Research Institute, Southern Federal University, 344090 Rostov-On-Don,Russia

2. Department of Chemistry, Dr. Harisingh Gour University, Sagar 470003, India; Correspondence:nutanshukla14@gmail.com

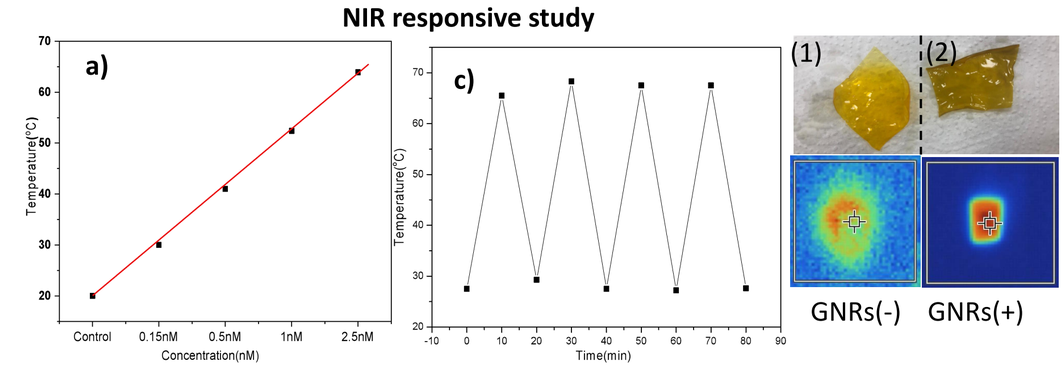
INTRODUCTION & AIM

Isolation of circulating tumor cells (CTCs) can be achieved through passive or active microfluidic approaches. Passive methods rely on channel structures, hydrodynamic forces, and steric hindrance, while active methods employ external fields such as electric, magnetic, acoustic, or optical forces. Processing complex biological samples like whole blood, however, limits the efficiency of single-module devices. To overcome this, hybrid microfluidic systems combining passive and active elements have emerged as powerful tools for label-free CTC enrichment, offering high sensitivity and multi-target capabilities.This study presents a near-infrared (NIR) light-responsive microfluidic platform designed for targeted capture and controlled release of CTCs. A thermoresponsive film integrated with gold nanorods (GNRs) was fabricated and fixed to a microchannel of varying lengths. To enhance capture specificity, cancer cell receptor molecules folic acid (FA) and hyaluronic acid (HA) were adsorbed onto the GNR film via a simple dipping process. Upon NIR irradiation at physiological temperature (≥37°C), the film undergoes rapid conformational change, enabling either site-specific release of individual CTCs through localized heating or bulk recovery of trapped cells. This platform demonstrates high capture efficiency, biocompatible release, and excellent cell survivability, offering a flexible strategy for CTC isolation and potential applications in precision anticancer therapies

METHOD



RESULTS & DISCUSSION



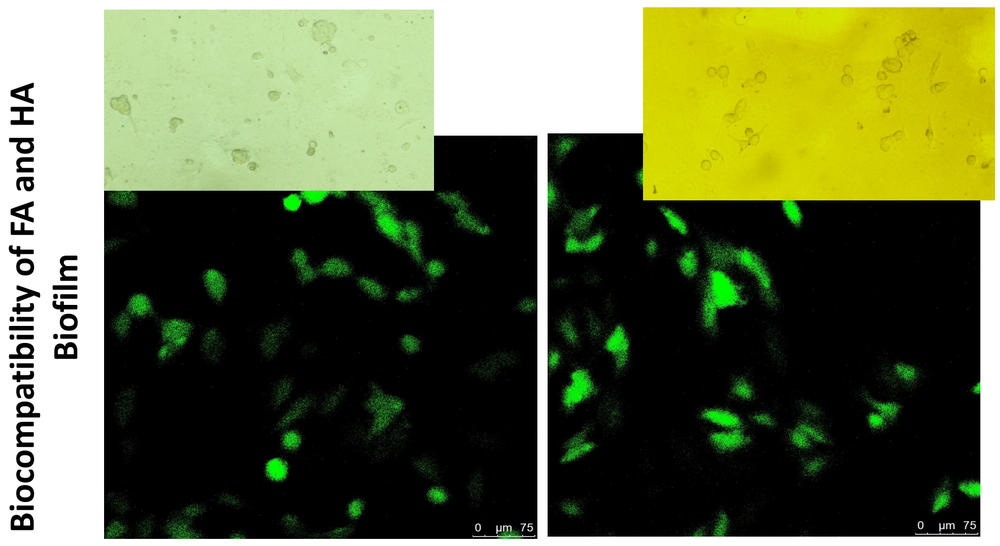
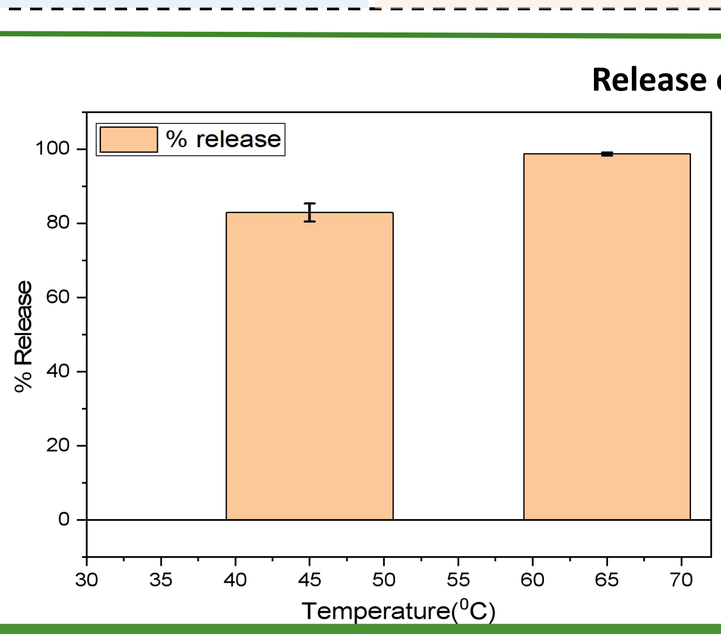


Figure caption: (1) tight cover, (2) support for membrane, (3) functionalized membrane, (4) microfluidic device with spiral channel (500 x 500 um²)



CONCLUSION

The developed NIR-responsive microfluidic platform integrates passive channel design with active photothermal control, enabling efficient capture and on-demand release of CTCs. Functionalization with FA and HA enhances specificity, while the thermoresponsive GNR film ensures high recovery rates and cell viability. This hybrid strategy not only addresses limitations of conventional single-module devices but also provides a versatile, label-free approach for CTC enrichment with strong potential in precision cancer diagnostics and therapies.

FUTURE WORK / REFERENCES

Future studies will focus on release of CTC isolation on HA biofilm and clinical validation with patient samples, miniaturization of the platform for point-of-care applications, and integration with downstream molecular analyses to enable comprehensive cancer profiling.