REVOLUTIONARY DIAGNOSTICS – NONTRADITIONAL APPROACHES FOR DEVELOPING BREAKTHROUGH CAPABILITIES AGAINST EMERGING THREATS

Programmable Magnetic Robot (promagbot) For Automated Nucleic Acid Extraction At The Point Of Need

Weihua Guan Penn State University **Tianyi Liu** Penn State University **Anthony Politza** Penn State University

Nucleic acid testing (NAT) remains the clinical standard for identifying and quantifying infectious diseases. However, the laboratory procedures for these methods require long waiting periods, trained staff, and expensive hardware to analyze the testing results. While necessary, complete NAT contains a bottleneck for point-of-need testing: sample preparation. Standard methods require extensive manual processes, laboratory devices, toxic chemicals, and trained professionals. These issues severely limit the scope of POC devices for providing quality NAT. Here we aim to develop an adaptable and customizable platform of nucleic acid extraction using charge switchable paramagnetic beads (PMBs). These methods will offer a unique solution to the bottleneck of sample preparation for areas of low resource by eliminating noxious chemicals and introducing automation. First, a microfluidic cartridge capable of being held and operated in the field must be developed for transportation of extraction reagents. Second, an enclosed device must be engineered to handle the magnetic beads within the cartridge and translocate them properly for extraction. Last, the performance of the entire system and protocols needs to be validated against standard extraction methods in comparison of yield and time.

Successful development of this device will provide an easy-to-use platform capable of unique RNA extraction. Introducing repeatable nucleic acid extraction into areas of low resource will increase the capabilities of all nucleic acid testing across the globe. While in this study we are solely studying the capabilities of ProMagBot for the extraction of HIV RNA, the platform is openly adaptable for other virus and nucleic acid extraction. The control algorithms can be adapted for any configuration of bead manipulation required. Thus, any extraction assay with paramagnetic beads can be used for RNA or DNA extraction from any number of sample mediums.

In this work, the microfluidic cartridge is constructed of layered PMMA to form an inner channel. That inner channel separates the extraction reagents using oil valves. The magnetic beads inside cartridge are manipulated by a permanent magnet that sits above them inside the device. This magnet is moved by electromagnetic coils. Overall, the system is automated by a control algorithm and computer vision software running on a Raspberry Pi 4. First, the microfluidic cartridge developed is capable of reagent separation by oil valve (Fig. 1). Subsequently, the cartridge remains very stable within the user's hand and can withstand being dropped. Figure 2 demonstrates that the magnetic robot is capable of two axis motion along four directions to complete a number of unique pathways. Last, in Figure 3 the ProMagBot device components are capable of all being powered by a compact lithium-polymer battery. As well, the extraction of HIV RNA can be achieved by ProMagBot (Fig. 3). To conclude, this work demonstrates a programmable magnetic robot (ProMagBot) capable of automated nucleic acid extraction. The entire ProMagBot system can be utilized in areas of low resources for nucleic acid extraction in under 15 minutes. We envision that this platform can be used in a number of broad applications to alleviate the strain of sample preparation at the point-of-need.

Funding for this work comes from the National Institutes of Health (R61AI147419), and the National Science Foundation (1902503; 1912410).