in any automated process. Further, the larger volumes of buffers and reagents used when processing large volume biological samples generates more waste. Having the capacity and ability to account for this waste presents an additional, unique technical hurdle for any automated process.

[0009] Further, because the current nucleic acid purification protocols are dependent upon hands-on, human interaction, there is an inherent risk of contamination, less consistency between sample preparation and processing runs, and an ongoing need for skilled technicians to perform these processes. Importantly, the nucleic acid purification on large scale is an extremely time-consuming procedure, distracting scientists from a central project or task. These factors, among others, are costly and inefficient— whether in an academic or clinical laboratory setting or within commercial enterprises.

[0010] Accordingly, there are a number of disadvantages and problems that can be addressed in automating nucleic acid purification, and there is an outstanding need for systems, methods, and devices that can automate the process of nucleic acid purification, particularly those that can incorporate all stages of the purification process into a single consumable element that limits or eliminates user intervention during the nucleic acid purification process.

[0011] Similarly, many analogous technical issues need to be addressed for automated protein purification as well. In protein purification, in addition to removing other cellular debris and materials from a protein of interest, there is also a need for the isolated/purified protein to maintain its biological activity. This often requires use of conditions and techniques that do not disrupt the tertiary structure of proteins, that retain any native posttranslational modifications of proteins (e.g. phosphorylation, glycosylation, cysteine disulfide bonds), and that do not introduce non-natural protein modifications (e.g. oxidation, deamidation). While this is difficult to achieve during hands on processes, the technical difficulties in automating protein purification are substantially more.

[0012] There is an outstanding need for systems, methods, and devices that can automate the process of protein purification, particularly those that can incorporate all stages of the purification process into a single consumable element that limits or eliminates user intervention during the protein purification process.

BRIEF SUMMARY

[0013] Implementations of the present disclosure may solve one or more of the foregoing or other problems in the art with automated isolation of target biomolecules, such as a target nucleic acid and/or a target protein, from biological and/or environmental sources.

[0013a] According to an aspect, there is provided system for automated purification of a target biomolecule from a biological sample, the system comprising a purification cartridge comprising: an input reservoir for receiving the biological sample; a first bioprocessing assembly in fluid communication with the input reservoir and a lysis buffer reservoir, the first bioprocessing assembly configured to generate a lysate comprising the target biomolecule; a second bioprocessing assembly in fluid communication with the first bioprocessing assembly and a first elution buffer reservoir, the second bioprocessing assembly including a target-biomolecule-binding filter configured to retain the target biomolecule; and a receptacle in fluid communication with the second bioprocessing assembly, the receptacle configured to receive an output container for receiving the target biomolecule from the second bioprocessing assembly; a casing having an internal compartment configured in size and shape for receiving the purification cartridge; a pump assembly disposed within the internal compartment and configured to provide pumping action; and a clamp mechanism disposed within the internal compartment and configured to move between an open position in which the internal compartment is accessible and a closed position in which the clamp mechanism is clamped against an inserted purification cartridge to enable processing of the biological sample, wherein when in the closed position, the clamp mechanism operates to fluidically seal the purification cartridge.

CLAIMS

1. A system for automated purification of a target biomolecule from a biological sample, the system comprising:

a purification cartridge comprising:

an input reservoir for receiving the biological sample;

a first bioprocessing assembly in fluid communication with the input reservoir and a lysis buffer reservoir, the first bioprocessing assembly configured to generate a lysate comprising the target biomolecule;

a second bioprocessing assembly in fluid communication with the first bioprocessing assembly and a first elution buffer reservoir, the second bioprocessing assembly including a target-biomolecule-binding filter configured to retain the target biomolecule; and

a receptacle in fluid communication with the second bioprocessing assembly, the receptacle configured to receive an output container for receiving the target biomolecule from the second bioprocessing assembly;

a casing having an internal compartment configured in size and shape for receiving the purification cartridge;

a pump assembly disposed within the internal compartment and configured to provide pumping action; and

a clamp mechanism disposed within the internal compartment and configured to move between an open position in which the internal compartment is accessible and a closed position in which the clamp mechanism is clamped against an inserted purification cartridge to enable processing of the biological sample, wherein when in the closed position, the clamp mechanism operates to fluidically seal the purification cartridge.

2. The system of claim 1, wherein the biological sample is a bacterial culture, a cell culture, a prokaryotic cell culture, a eukaryotic cell culture, a clinical sample, an environmental sample, a food sample, or a beverage sample.

3. The system of claim 1, further comprising an optical density detector window disposed between the input reservoir and the first bioprocessing assembly, the optical density detector window being configured to allow detection of an optical density of the biological sample.

4. The system of claim 1, wherein the first bioprocessing assembly comprises a clarification filter.

5. The system of claim 4, wherein the clarification filter is in fluid communication with the input reservoir and the lysis buffer reservoir, the clarification filter being configured to separate a target-nucleic-acid-containing portion of the biological sample from a first waste portion of the biological sample.

6. The system of claim 4, wherein the first bioprocessing assembly comprises a cell capture filter, wherein the cell capture filter is disposed upstream of the clarification filter.

7. The system of claim 6, wherein the cell capture or clarification filter is in fluid communication with the input reservoir and the lysis buffer reservoir, the cell capture or clarification filter being configured to separate a target-nucleic-acid-containing portion of the biological sample from a first waste portion of the biological sample.

8. The system of claim 6, wherein the lysis buffer reservoir is fluidically coupled to the cell capture filter to enable backwashing of the cell capture filter and passage of backwash to the clarification filter.

9. The system of claim 8, further comprising a first mixing chamber disposed between the clarification filter and the cell capture filter, the first mixing chamber configured to receive the backwash.

10. The system of claim 9, further comprising a neutralization buffer reservoir in fluid communication with the first mixing chamber, the first mixing chamber being configured to receive the backwash and a neutralization buffer and to provide mixing of the backwash and the neutralization buffer to form a neutralized lysate.

11. The system of claim 10, wherein the clarification filter is in fluid communication with the first mixing chamber, the clarification filter being configured to separate a second waste portion from the target-nucleic-acid-containing portion of the biological sample.

12. The system of claim 8, wherein the clarification filter comprises the cell capture filter, the cell capture filter being configured to concentrate a cellular component of the biological sample at a first purification step and to clarify the neutralized lysate at a second, later purification step.

13. The system of claim 1, wherein the target-biomolecule-binding filter of the second bioprocessing assembly comprises a silica-based filter or a column of beads having affinity for the target nucleic acid.

14. The system of claim 13, wherein the second bioprocessing assembly further comprises a purification reagent reservoir in fluid communication with the target-biomolecule-binding filter.

15. The system of claim 13, wherein the target-biomolecule-binding filter is in fluid communication with the elution buffer reservoir and the output container.

16. The system of claim 9, wherein the second bioprocessing assembly comprises a second mixing chamber disposed between the first bioprocessing assembly and the target-biomolecule-binding filter.

17. The system of claim 16, wherein the second mixing chamber is in fluid communication with an endotoxin removal buffer reservoir.

18. The system of claim 16, wherein the target-biomolecule-binding filter is the nucleic-acid binding filter comprising an anion exchange membrane.

19. The system of claim 18, wherein the second bioprocessing assembly comprises a precipitator membrane disposed downstream of the anion exchange membrane.

20. The system of claim 19, wherein the anion exchange membrane is configured to separate a third waste portion from the target-nucleic-acid-containing portion of the biological sample.

21. The system of claim 19, further comprising a second elution buffer reservoir, the first elution buffer reservoir being fluidically coupled to the anion exchange membrane to enable

elution of the target nucleic acid from the anion exchange membrane, and the second elution buffer reservoir being fluidically coupled to the precipitator membrane to enable elution of the target nucleic acid from the precipitator membrane.

22. The system of claim 19, wherein the precipitator membrane is configured to separate a fourth waste portion from the target-nucleic-acid-containing portion of the biological sample.

23. The system of claim 19, wherein the precipitator membrane is in fluid communication with a precipitation reagent reservoir, the precipitation reagent reservoir optionally comprising isopropanol.

24. The system of claim 19, wherein the precipitator membrane is in fluid communication with a wash/desalting solution reservoir, the wash/desalting solution reservoir optionally comprising about 70% ethanol.

25. The system of claim 19, wherein the second bioprocessing assembly comprises a third mixing chamber disposed between and in fluid communication with the anion exchange membrane and the precipitator membrane, wherein the third mixing chamber is fluidically coupled to the precipitation reagent reservoir and/or the desalting solution reservoir and is disposed between the precipitator membrane and the precipitation reagent reservoir and/or the desalting solution reservoir.

26. The system of claim 1, wherein the output container is selectively detachable from the apparatus.

27. The system of claim 1, wherein the input reservoir is sized and shaped to receive at least 5 mL, preferably at least 100 ml, or up to 2 L of biological sample.