CLAIMS

WHAT IS CLAIMED IS:

1. A method for simultaneously purifying nucleic acids from at least two different samples comprising:

(a) loading into a first channel of a microfluidic chip (i) a first sample comprising first nucleic acids and a first contaminant, (ii) a first trailing electrolyte buffer comprising first trailing ions, wherein a magnitude of an effective mobility of said first trailing ions is less than a magnitude of an effective mobility of said first nucleic acids, and (iii) a first leading electrolyte buffer comprising first leading ions, wherein a magnitude of an effective mobility of said first leading ions is greater than said magnitude of said effective mobility of said first nucleic acids;

(b) loading into a second channel of said microfluidic chip (i) a second sample comprising second nucleic acids and a second contaminant, (ii) a second trailing electrolyte buffer comprising second trailing ions, wherein a magnitude of said second trailing ions is less than a magnitude of an effective mobility of said second nucleic acids, and (iii) a second leading electrolyte buffer comprising second leading ions, wherein a magnitude of an effective mobility of said second leading ions is greater than said magnitude of said effective mobility of said second nucleic acids; and

(c) independently controlling a first electric circuit connected to said microfluidic chip to conduct isotachophoresis in said first channel with said first trailing ions, said first nucleic acids, and said first leading ions, and independently controlling a second electric circuit to conduct isotachophoresis in said second channel with said second trailing ions, said second nucleic acids, and said second leading ions, thereby simultaneously purifying said first nucleic acids from said first contaminant and said second nucleic acids from said second contaminant.

2. The method of claim 1, wherein said first trailing electrolyte buffer or said first leading electrolyte buffer further comprises a cell lysis agent or a tissue disruption agent.

3. The method of claim 1 or 2, wherein said lysis agent or said tissue disruption agent comprises one or more agents selected from the group consisting of: a solution with pH greater than about 12, a proteinase, urea, thiourea, and a surfactant.

4. The method of any one of claims 1 to 3, wherein said first sample comprises lysed solid tissue or lysed cells.

5. The method of any one of claims 1 to 4, wherein said first sample does not contact said second sample during said conducting of isotachophoresis.

6. The method of any one of claims 1 to 5, further comprising:

(d) loading into a third channel of said microfluidic chip (i) a third sample comprising third nucleic acids and a third contaminant, (ii) a third trailing electrolyte buffer comprising third trailing ions, wherein a magnitude of an effective mobility of said third trailing ions is less than a magnitude of an effective mobility of said third nucleic acids, and (iii) a third leading electrolyte buffer comprising third leading ions, wherein a magnitude of an effective mobility of said third leading ions is greater than said magnitude of said effective mobility of said third nucleic acids, and

(e) independently controlling a third electric circuit connected to said microfluidic chip to conduct isotachophoresis in said third channel with said third trailing ions, said third nucleic acids, and said third leading ions, thereby simultaneously purifying said first nucleic acids from said first contaminant, said second nucleic acids from said second contaminant, and said third nucleic acids from said third contaminant.

7. The method of any one of claims 1 to 6, wherein said first and second electric circuits are generated from different sets of electrodes.

8. The method of any one of claims 1 to 7, wherein said first and second channels are coupled to independent sensors.

9. The method of claim 8, wherein feedback signals from said independent sensors is used to independently control said first and second electric circuits.

10. The method of claim 8, wherein said independent sensors detect voltage and said feedback signals are used to control current within said first and second channels.

11. The method of claim 8, wherein said independent sensors detect current and said feedback is used to control voltage within said first and second channels.

12. The method of any one of claims 1 to 11, wherein each channel has a dedicated set of electrodes and electric circuitry to drive isotachoporesis.

13. The method of any one of claims 1 to 12, wherein said first nucleic acids comprise DNA.

14. The method of any one of claims 1 to 12, wherein said first nucleic acids comprise RNA.

15. The method of any one of claims 1 to 14, wherein said first sample or said second sample comprises fixed cells, fixed tissue, or embedded tissue.

16. The method of any one of claims 1 to 15, further comprising third and fourth channels in liquid communication with said first and second channels, respectively, wherein said third and fourth channels comprise first and second elution buffers, respectively, and wherein the method further comprises, after independently controlling said first and second electric circuits, applying said first electric circuit or a third electric circuit to conduct isotachophoresis in said third channel, and applying said second electric circuit or a fourth electric circuit in said fourth channel, respectively.

17. The method of claim 16, further comprising eluting a first output solution comprising said purified first nucleic acid from a first outlet reservoir of said first elution channel and eluting a second output solution comprising said purified second nucleic acids from a second outlet reservoir of said second elution channel.

18. A microfluidic system comprising:

(a) a first isotachophoresis region in a microfluidic chip comprising:

i. a first fluidic channel,

ii. a first sample reservoir,

iii. a first buffer reservoir, and

iv. a second buffer reservoir,

wherein said first fluidic channel, said first sample reservoir, said first buffer reservoir, and said second buffer reservoir are in liquid communication with each other; and

(b) a second isotachophoresis region in said microfluidic chip comprising:

i. a second fluidic channel,

ii. a second sample reservoir,

iii. a third buffer reservoir, and

iv. a fourth buffer reservoir,

wherein said second fluidic channel, said second sample reservoir, said third buffer reservoir, and said fourth buffer reservoir are in liquid communication with each other,

wherein said first isotachophoresis region is not in liquid communication with said second isotachophoresis region, and

wherein said microfluidic system is configured to independently control a first electric circuit that applies current to said first isotachophoresis region and a second electric circuit that applies current to said second isotachophoresis region.

19. The microfluidic system of claim 18, wherein said first fluidic channel is coupled to a first independent sensor and second fluidic channel is coupled to a second independent sensor.

20. The microfluidic system of claim 18 or 19, wherein a first feedback signal from said first independent sensor is configured to independently control said first electric circuit and a second feedback signal from said second independent sensor is used to independently control second electric circuit.

21. The microfluidic system of any one of claims 18 to 20, wherein said first feedback signal is used to independently control current within said first fluidic channel and said second feedback signal is used to independently control current within said second fluidic channel.

22. The microfluidic system of any one of claims 18 to 20, wherein said first feedback signal is used to independently control voltage within said first fluidic channel and said second feedback signal is configured to independently control voltage within said second fluidic channel.

23. The microfluidic system of any one of claims 18 to 22, wherein each fluidic channel has a dedicated set of electrodes and electric circuitry to drive isotachophoresis.

24. The microfluidic system of any one of claims 18 to 23, wherein said microfluidic system is configured to control said first electric circuit simultaneously with said second electric circuit and independently of said second electric circuit.

25. The microfluidic system of any one of claims 18 to 24, further comprising first and second elution reservoirs, each in liquid communication with said first and second channels, respectively, wherein temperature sensors are situated within 10 mm of each of said elution reservoirs.

26. The microfluidic system of claim 25, wherein said microfluidic system is configured to independently control each of a first electric circuit that applies current between said first buffer reservoir and said first elution reservoir, and a second electric circuit that applies current between said second buffer reservoir and said second elution reservoir.

27. The microfluidic system of any one of claims 18 to 26, wherein a leakage rate between said first and second isotachophoresis zones is less than 1 µl per hour.

28. The microfluidic system of any one of claims 18 to 27, wherein current leakage between said first and second regions is less than 1 uA.

29. The microfluidic system of any one of claims 18 to 28, wherein an electrical impedance between said first and second channels is greater than 0.1 megaOhm.

30. The microfluidic system of any one of claims 18 to 29, wherein said first fluidic channel holds a liquid volume greater than 100 µl.