

WHAT IS CLAIMED IS:

1. A system for measuring a product quality attribute of an analyte of a biological sample, the system comprising:
 - a first flow control device;
 - a sample purification device in fluid communication with the first flow control device;
 - a second flow control device in fluid communication with the first flow control device, with the sample purification device, and with first and second sample analyzers, wherein the first sample analyzer comprises a first chromatography column; and
 - a control unit coupled to the first and second flow control devices and configured so that during operation of the system, the control unit:
 - (a) adjusts a configuration of the first flow control device to direct a portion of a biological sample from the first flow control device into either the sample purification device or into the second flow control device, so that the portion of the biological sample is received in the second flow control device;
 - (b) adjusts a configuration of the second flow control device to direct the portion of the biological sample to one of the first and second sample analyzers; and
 - (c) determines a product quality attribute of an analyte of the biological sample based on an analysis of the portion of the biological sample by the one of the first and second sample analyzers.
2. The system of claim 1, wherein the first chromatography column is a cation exchange chromatography column.
3. The system of claim 1, wherein the first chromatography column is a size exclusion chromatography column.
4. The system of claim 1, wherein the first chromatography column is a reversed phase chromatography column.
5. The system of claim 1, wherein the sample purification device comprises an affinity chromatography column.

6. The system of claim 1, wherein the second sample analyzer comprises a quantification detector configured to generate an electrical signal representative of an amount of an analyte in the biological sample.
7. The system of claim 6, wherein the first chromatography column is in fluid communication with the quantification detector, and wherein the quantification detector is configured to generate an electrical signal representative of an amount of the analyte in an eluate stream from the first chromatography column.
8. The system of claim 1, wherein the first sample analyzer comprises a quantification detector in fluid communication with the first chromatography column and configured to generate an electrical signal representative of an amount of an analyte in an eluate stream from the first chromatography column.
9. The system of claim 1, wherein the second sample analyzer comprises a second chromatography column, and wherein the second chromatography column is different from the first chromatography column and is one of a cation exchange chromatography column, a size exclusion chromatography column, a reversed phase chromatography column, and a hydrophilic interaction chromatography column.
10. The system of claim 9, wherein the second flow control device is in fluid communication with a third sample analyzer comprising a third chromatography column, and wherein the third chromatography column is different from the first and second chromatography columns and is one of a cation exchange chromatography column, a size exclusion chromatography column, a reversed phase chromatography column, and a hydrophilic interaction chromatography column.
11. The system of claim 1, wherein the second flow control device is in fluid communication with four additional sample analyzers, each of the four additional sample analyzers comprising a chromatography column that is different from the first chromatography column and from chromatography columns of the others of the four additional sample analyzers.

12. The system of claim 1, wherein the product quality attribute of the analyte is a concentration of the analyte in the biological sample.
13. The system of claim 1, wherein the product quality attribute of the analyte is a measure of aggregation of the analyte in the biological sample.
14. The system of claim 1, wherein the product quality attribute of the analyte is a measure of charge variants or heterogeneity of the analyte in the biological sample.
15. The system of claim 1, wherein the product quality attribute of the analyte is a measure of purity or integrity of the analyte in the biological sample.
16. The system of claim 5, wherein the affinity chromatography column is one of a Protein A chromatography column, a Protein G chromatography column, and a receptor binding column.
17. The system of claim 1, wherein the analyte comprises a protein in the biological sample.
18. The system of claim 1, wherein the protein comprises an antibody in the biological sample.
19. The system of claim 9, further comprising a column manager in fluid communication with the first and second sample analyzers and with the second flow control device, and coupled to the control unit, wherein the control unit is configured to adjust a configuration of the column manager to direct the portion of the biological sample into one of the first and second sample analyzers.
20. The system of claim 10, further comprising a column manager in fluid communication with the first, second, and third sample analyzers and with the second flow control device, and coupled to the control unit, wherein the control unit is configured to adjust a configuration of the column manager to direct the portion of the biological sample into one of the first, second, third, and fourth sample analyzers.

21. The system of claim 1, wherein the portion of the biological sample is a first portion and the product quality attribute is a first product quality attribute, and wherein the control unit is configured so that during operation of the system, the control unit:

(d) adjusts a configuration of the first flow control device to direct a second portion of the biological sample from the first flow control device into either the sample purification device or into the second flow control device, so that the second portion of the biological sample is received in the second flow control device;

(e) adjusts a configuration of the second flow control device to direct the second portion of the biological sample to one of the first and second sample analyzers that did not receive the first portion of the biological sample; and

(f) determines a second product quality attribute of the analyte of the biological sample based on an analysis of the second portion of the biological sample by the one of the first and second sample analyzers that received the second portion of the biological sample.

22. The system of claim 21, wherein the first and second product quality attributes are different, and wherein the first and second product quality attributes are each selected from the group consisting of a concentration of the analyte in the biological sample, a measure of aggregation of the analyte in the biological sample, a measure of charge variants or heterogeneity of the analyte in the biological sample, and a measure of purity or integrity of the analyte in the biological sample.

23. The system of claim 9, wherein the portion of the biological sample is a first portion and the product quality attribute is a first product quality attribute, and the control device is configured to repeat steps (a)-(c) with another portion of the biological sample to determine two different product quality attributes for the analyte of the biological sample.

24. The system of claim 9, wherein the portion of the biological sample is a first portion and the product quality attribute is a first product quality attribute, and the control device is configured to repeat steps (a)-(c) with two other portions of the biological sample to determine three different product quality attributes for the analyte of the biological sample.

25. The system of claim 10, wherein the portion of the biological sample is a first portion and the product quality attribute is a first product quality attribute, and the control device is

configured to repeat steps (a)-(c) with another portion of the biological sample to determine two different product quality attributes for the analyte of the biological sample.

26. The system of claim 10, wherein the portion of the biological sample is a first portion and the product quality attribute is a first product quality attribute, and the control device is configured to repeat steps (a)-(c) with three other portions of the biological sample to determine four different product quality attributes for the analyte of the biological sample.

27. The system of any one of claims 23-26, wherein the product quality attributes are each selected from the group consisting of a concentration of the analyte in the biological sample, a measure of aggregation of the analyte in the biological sample, a measure of charge variants or heterogeneity of the analyte in the biological sample, and a measure of purity or integrity of the analyte in the biological sample.

28. The system of claim 1, further comprising a sampling device coupled to the control unit and configured to receive the biological sample, and to deliver the portion of the biological sample to the first fluid control device.

29. The system of claim 28, wherein the sampling device comprises a container interface configured to receive the biological sample in a container.

30. The system of claim 28, wherein the sampling device comprises a fluidic channel configured to receive the biological sample, and wherein the control unit is configured so that during operation of the system, the control unit transmits a signal to the sampling device to cause the sampling device to discharge the portion of the biological sample from the fluidic channel into the first flow control device.

31. The system of claim 9, further comprising:
a pump in fluid communication with the second flow control device, with the first and second sample analyzers, and with first and second buffer reservoirs associated respectively with the first and second sample analyzers,

wherein the control unit and pump are configured so that during operation of the system, the pump delivers a buffer solution to the one of the first and second sample

analyzers from a corresponding associated buffer reservoir when the portion of the biological sample is directed into the one of the first and second sample analyzers.

32. The system of claim 10, further comprising:

a pump in fluid communication with the second flow control device, with the first, second, and third sample analyzers, and with first, second, and third buffer reservoirs associated respectively with the first, second, and third sample analyzers,

wherein the control unit and pump are configured so that during operation of the system, the pump delivers a buffer solution to the one of the first, second, and third sample analyzers from a corresponding associated buffer reservoir when the portion of the biological sample is directed into the one of the first, second, and third sample analyzers.

33. The system of claim 1, further comprising:

a pump in fluid communication with the second flow control device, the first sample analyzer, and with a buffer reservoir associated with the first sample analyzer,

wherein the first chromatography column is a cation exchange column; and

wherein the control unit and pump are configured so that during operation of the system, the pump delivers an acetate buffer to the first chromatography column to propagate the portion of the biological sample along the first chromatography column.

34. The system of claim 33, wherein the acetate buffer has a pH of 4.0 or less.

35. The system of claim 1, wherein the biological sample is a harvest medium extracted from a bioreactor.

36. The system of claim 1, wherein the biological sample is an intermediate or product solution from a bio-manufacturing system.

37. The system of claim 1, wherein the biological sample is a portion of a cell culture.

38. The system of claim 6, wherein the quantification detector comprises a diode array detector.

39. The system of claim 6, wherein the quantification detector comprises a spectrometric detector configured to measure absorbance information for the portion of the biological sample.
40. The system of claim 6, wherein the quantification detector comprises a fluorescence detector.
41. The system of claim 6, wherein the quantification detector comprises a mass spectrometric detector.
42. A system for measuring product quality attributes for an analyte of a biological sample, the system comprising:
- a first flow control device;
 - a sample purification device comprising a purification chromatography column in fluid communication with the first flow control device;
 - a second flow control device in fluid communication with the first flow control device and with the sample purification device;
 - a first sample analyzer comprising a first chromatography column in fluid communication with the second flow control device;
 - a second sample analyzer comprising a second chromatography column in fluid communication with the second flow control device;
 - a third sample analyzer comprising a third chromatography column in fluid communication with the second flow control device;
 - a fourth sample analyzer comprising a quantification detector; and
 - a control unit coupled to the first and second flow control devices and configured so that during operation of the system, the control unit:
 - (a) adjusts a configuration of the first flow control device to direct a first portion of a biological sample from the first flow control device into either the sample purification device or into the second flow control device, so that the portion of the biological sample is received in the second flow control device;
 - (b) adjusts a configuration of the second flow control device to direct the first portion of the biological sample to one of the first, second, third, and fourth sample analyzers;

(c) determines a first product quality attribute of an analyte of the biological sample based on an analysis of the portion of the biological sample by the one of the first, second, third, and fourth sample analyzers; and

(d) repeats steps (a)-(c) with three additional portions of the biological sample, adjusting the configuration of the second flow control device so that each portion of the biological sample is directed to a different one of the sample analyzers, to determine a total of four product quality attributes of the analyte of the biological sample.

43. The system of claim 42, wherein each of the four product quality attributes is different.

44. The system of claim 42, wherein each of the first, second, and third chromatography columns is a different type of column.

45. The system of claim 44, wherein the first chromatography column is cation exchange column, the second chromatography column is a size exclusion column, and the third chromatography column is a reversed phase column or a hydrophilic interaction column.

46. The system of claim 42, wherein the first sample analyzer determines information about a measure of charge variants or heterogeneity of the analyte in the biological sample, wherein the second sample analyzer determines information about a measure of aggregation of the analyte in the biological sample, wherein the third sample analyzer determines information about a measure of purity or integrity of the analyte in the biological sample, and wherein the fourth sample analyzer determines information about a concentration of the analyte in the biological sample.

47. The system of claim 42, wherein the four quality attributes comprise a measure of charge variants or heterogeneity of the analyte in the biological sample, a measure of aggregation of the analyte in the biological sample, a measure of purity or integrity of the analyte in the biological sample, and a concentration of the analyte in the biological sample.

48. The system of claim 42, wherein the first chromatography column is a cation exchange chromatography column, the second chromatography column is a size exclusion

chromatography column, and the third chromatography column is a reversed phase chromatography column.

49. The system of claim 42, wherein the sample purification device comprises an affinity chromatography column.

50. The system of claim 42, wherein the four product quality attributes comprise a concentration of the analyte in the biological sample, a measure of aggregation of the analyte in the biological sample, a measure of charge variants or heterogeneity of the analyte in the biological sample, and a measure of purity or integrity of the analyte in the biological sample.

51. The system of claim 42, wherein the analyte comprises a protein in the biological sample.

52. The system of claim 51, wherein the protein comprises an antibody in the biological sample.

53. The system of claim 42, further comprising a column manager in fluid communication with the first, second, and third sample analyzers and with the second flow control device, and coupled to the control unit, wherein the control unit is configured to adjust a configuration of the column manager to direct the portion of the biological sample into one of the first, second, and third sample analyzers.

54. The system of claim 42, further comprising a sampling device coupled to the control unit and configured to receive the biological sample, and to deliver the portion of the biological sample to the first fluid control device.

55. The system of claim 42, wherein the quantification detector comprises one of a diode array detector, a spectrometric detector configured to measure absorbance information for the portion of the biological sample, a fluorescence detector, and a mass spectrometric detector.

56. A method for measuring product quality attributes of an analyte of a biological sample, the method comprising:

obtaining a biological sample by extracting the biological sample from an operating bioreactor or from a purification apparatus in fluid communication with the operating bioreactor;

directing a first portion of the biological sample to a first sample analyzer and obtaining information about a first product quality attribute of an analyte of the biological sample by analyzing the first portion of the biological sample in the first sample analyzer;

directing a second portion of the biological sample to a second sample analyzer and obtaining information about a second product quality attribute of an analyte of the biological sample by analyzing the second portion of the biological sample in the second sample analyzer,

wherein the first and second product quality attributes are different; and

wherein at least one of the first and second product quality attributes comprises a measure of charge variants or heterogeneity of the analyte in the biological sample, a measure of aggregation of the analyte in the biological sample, a measure of purity or integrity of the analyte in the biological sample, and a concentration of the analyte in the biological sample.