complex to configure and use for preparing samples and conducting a variety of different analyte assays, without requiring the expertise of LCMS technologists, or the massive scale of a reference laboratory. There is yet also a need for a sample preparation and sample analysis systems that improve the efficiency of the time to result for a variety of different analyte assays.

SUMMARY OF THE INVENTION

[0009] Embodiments of t~~T~~he present invention overcome~~s~~ the foregoing problems and other shortcomings, drawbacks, and challenges of conventional sample preparation and sample analysis systems. While the invention will be described in connection with certain embodiments, it will be understood that the invention is not limited to these embodiments. To the contrary, embodiments of this invention include~~s~~ all alternatives, modifications, and equivalents as may be included within the spirit and scope of the present invention.

[0010] ~~In accordance with one embodiment of the present invention, a sample preparation and analysis system includes a sample preparation system and a sample analysis system. The sample preparation system prepares samples in accordance with an assay that is selected from a database containing a plurality of unique assays. The sample analysis system includes an analyzer that is dynamically reconfigurable based on the selected assay so as to analyze the prepared sample in accordance with that selected assay. A data communication link communicates data from the sample preparation system to the sample analysis system to reconfigure the analyzer in accordance with the selected assay.~~In one aspect, there is provided a sample preparation and analysis system, comprising: a sample preparation system including at least one of a mixing station, an incubation station, and a matrix removal station and configured to prepare a sample in accordance with sample preparation information for a selected assay stored in a database, said database containing stored information pertaining to a plurality of unique assays; a sample analysis system comprising an analyzer, the analyzer being dynamically reconfigurable in response to the selected assay to analyze the prepared sample in accordance with the selected assay; and a data communication link configured to communicate data from the sample preparation system to the

sample analysis system that reconfigures the analyzerin accordance with the selected assay.

[0011] ~~According to another embodiment of the present invention, a method of preparing and analyzing a sample includes preparing a sample with a sample preparation system and analyzing the prepared sample with a sample analysis system. The sample is taken from a specimen in accordance with an assay that is selected from a database containing a plurality of unique assays. The sample analysis system includes an analyzer, which is dynamically reconfigured in response to the selected assay and analyzes the prepared sample in that regard. Data to dynamically reconfigure the analyzer is communicated between the sample preparation system and the sample analysis system over a data communication link.~~In another aspect, there is provided a method of preparing and analyzing a sample, comprising: preparing, with a sample preparation system including at least one of a mixing station, an incubation station, and a matrix removal station and, a sample taken from a specimen in accordance with sample preparation information for a selected assay stored in a database, said database containing stored information pertaining to a plurality of unique assays; dynamically reconfiguring an analyzer of a sample analysis system in response to the selected assay to analyze the prepared sample in accordance with the selected assay; analyzing the prepared sample with the analyzer in accordance with the selected assay; and communicating data between the sample preparation system and the sample analysis system over a data communication link, the data being used to reconfigure the analyzer in accordance with the selected assay.

[0012] Disclosed herein is~~Another embodiment of the present invention is directed to~~ a sample preparation and analysis system that includes a sample preparation station and a sample analysis station. The sample preparation system prepares samples in

accordance with an assay that is selected from a database containing a plurality of unique assays. The sample analysis system includes an analyzer that is dynamically reconfigurable based on the selected assay so as to analyze the prepared sample in accordance with that selected assay. A transport mechanism transports the prepared sample from the sample preparation system to the sample analysis system.

[0013] Disclosed herein is ~~Still another embodiment of the present invention is directed to~~ a method to prepare and analyze a sample by a sample preparation system and sample analysis system, respectively. The sample is taken from a specimen in accordance with an assay that is selected from a database containing a plurality of unique assays. The sample analysis system includes an analyzer, which is dynamically reconfigured in response to the selected assay and analyzes the prepared sample in that regard. A transport mechanism transports the prepared sample from the sample preparation system to the sample analysis system.

[0014] Disclosed herein is ~~In accordance with another embodiment of the present invention,~~ an encapsulated sample preparation and analysis system having a sample preparation system and a sample analysis system that includes a controller. The controller controls the operation the sample preparation system as well as the operation of a portion of the sample analysis system. Operation of the sample preparation system and the portion of the sample analysis system are in accordance with an assay, which is selected from a database containing a plurality of unique assays.

[0015] Disclosed herein is ~~According to another embodiment of the present invention,~~ an encapsulated sample preparation and analysis system that includes a controller. The controller is configured to dynamically and automatically vary one or more parameters of a sample preparation system in order to prepare samples in accordance with respective assays. The assays are selected from a database containing a plurality of unique assays.

[0016] Disclosed herein is ~~Yet another embodiment of the present invention is directed to~~ an automated sample preparation and analysis system that includes a sample preparation system and a sample analysis system. The sample preparation station prepares a sample, taken from a specimen, in accordance with an assay that is selected from a plurality of unique assays. The sample analysis system is configured to analyze the prepared sample according to the selected assay.

Sequencing of the preparation of the samples in the sample preparation system and analysis by the sample analysis system is controlled by a controller.

[0017] Disclosed herein is~~Still another embodiment of the present invention includes~~ a method of preparing and analyzing samples taken from specimens. The method includes sequencing the samples for preparation, which is in accordance with respective assays selected from a database containing a plurality of unique assays. The method further includes sequencing the analysis of the prepared samples, which is also in accordance with the respective assays.

[0018] Disclosed herein is~~In accordance with another embodiment of the present invention,~~ an automated sample preparation and analysis system that includes a sample preparation system and a sample analysis system. The sample preparation system prepares a sample taken from a specimen in accordance with an assay, which is selected from a database containing a plurality of unique assays. The sample analysis system is configured to analyze the prepared sample in accordance with the selected assay. A controller dynamically sequences the prepared sample for analysis by the sample analysis system.

[0019] Disclosed herein is~~Another embodiment of the present invention is directed to~~ a method of preparing and analyzing samples taken from specimens. The method includes dynamically sequencing the analysis of the prepared samples according to respective assays selected from a database containing a plurality of unique assays.

[0020] Disclosed herein is~~Another embodiment of the present invention is directed to~~ a method of preparing and analyzing samples. The method includes querying a first controller with a second controller to determine a plurality of unique assays that may be performed by the sample analysis station. A human perceptible indication of the plurality of unique assays is provided.

[0021] Disclosed herein is~~Yet another embodiment of the present invention is directed to~~ a method of preparing a sample by receiving a specimen and automatically determining a test to be performed on the sample. The test is in accordance with an assay selected from a database containing a plurality of unique assays. A plurality of preparation steps is determined in response to the selection of the assay. The preparation steps prepare the sample for analysis.

[0022] Disclosed herein is~~Still another embodiment of the present invention is directed to~~ a method of preparing a sample. The method includes receiving a specimen and then, automatically, determining a target time to prepare a sample from the specimen.

The target time to prepare is indicative of a time at which preparation of the sample should be complete.

[0023] Disclosed herein is~~In accordance with another embodiment of the present invention,~~ a method of analyzing a sample that includes receiving a specimen. The sample is prepared from the specimen and then, automatically, determining a target time to result. The target time to result is indicative of a time at which the analysis of the prepared sample is returned.

[0024] Disclosed herein is~~In accordance with yet another embodiment of the present invention,~~ a method of multiplexing the operation of a sample preparation and analysis system that includes preparing first and second prepared samples with a sample preparation station. The first prepared sample is prepared in accordance with a first assay, and the second prepared sample is prepared in accordance with a second assay. The first and second assays are selected from a database containing a plurality of unique assays. The first and second prepared samples are transported, separately, to a sample analysis station having first and second separation channels and an analyzer. The first prepared sample is analyzed in accordance with the first selected assay. While analyzing the first prepared sample, the second prepared sample is being separated with the second separation channel and in accordance with the second selected assay.

[0025] Disclosed herein is~~According to still another embodiment of the present invention,~~ a method of multiplexing a sample preparation and analysis system having a sample preparation system and a sample analysis system that includes determining a sample analysis system readiness. The sample analysis system is configured to analyze a plurality of prepared samples with a mass spectrometer. The injection of the plurality of prepared samples into one a plurality of injection ports is sequenced. Each of the plurality of injection ports is coupled to a respective separation channel. The sequencing is in accordance with information associated with the respective one of the plurality of prepared samples and the sample analysis system readiness.

[0026] Disclosed herein is~~According to another embodiment of the present invention,~~ a method of multiplexing a sample preparation and analysis system having a sample preparation system and a sample analysis system that includes receiving a specimen at the sample preparation system. An indication of an assay associated with the specimen is automatically determined such that an assay corresponding to the indication of the assay is selected from a database containing a plurality of unique assays. A sample

is taken from the specimen in accordance with the selected assay with the sample preparation system. A mass spectrometer and/or a separation channel of the sample analysis system are dynamically reconfigured according to the selected assay. The reconfigured sample analysis system processes the prepared sample according to the selected assay.

[0027] Disclosed herein is~~One embodiment of the present invention is directed to~~ a sample preparation and analysis system that is configured to inhibit evaporation of volatile liquids used therein. The sample preparation and analysis system includes a sample preparation system that is configured to receive a plurality of openable sample vessels, wherein each of the openable sample vessels is configured to be opened and to receive a sample and/or a volatile liquid therein. The openable sample vessel is then closed to inhibit evaporation of the volatile liquid.

[0028] Disclosed herein is~~Another embodiment of the present invention is directed to~~ a sample preparation and analysis system~~. That~~ that includes a sample preparation station and a sample analysis station. The sample preparation station prepares a sample taken from a specimen for analysis in accordance with an assay. The assay is selected from a database containing a plurality of unique assays. The sample preparation system includes a first controller to control at least a portion of the operation of the sample preparation system. The sample analysis system analyzes the prepared sample using an analyzer configured in accordance with the selected assay. The sample analysis system further includes a second controller to control at least a portion of the operation of the sample analysis system. A software data communication link and a hardware data communication link each communicate data between the first and second controllers.

[0029] Disclosed herein is~~Still another embodiment of the present invention is directed to~~ a method of preparing and analyzing a sample. The method includes preparing a sample for analysis by mass spectrometry by a sample preparation system. The sample is prepared in accordance with an assay selected from a database containing a plurality of unique assays. The sample preparation system includes a first controller to control at least a portion of the operation of the sample preparation system. A mass spectrometer analyzes the prepared sample in accordance with the selected assay and includes a second controller to control at least a portion of the operation of the mass spectrometer. Data associated with the prepare sample is communicated between the first and second controllers via at least a portion of a

data communication link, which includes a software data link and a hardware data link.

[0030] Disclosed herein is~~Yet another embodiment of the present invention is directed to~~ an automated sample preparation and analysis system having a sample preparation system and a sample analysis system. The sample preparation system prepares a sample for an assay, which is selected from a database comprising a plurality of unique assays. The sample analysis system includes a mass spectrometer for analyzing the prepared sample in accordance with the selected assay. First and second controllers are configured to control at least a portion of the sample preparation system and the sample analysis system, respectively. The second controller is further configured to send result data to the first controller.

[0031] Disclosed herein is~~In accordance with another embodiment of the present invention,~~ a method to prepare and analyze a sample that includes preparing a sample for an assay with a sample preparation system. The assay is selected from a database containing a plurality of unique assays. A sample analysis system, which includes a mass spectrometer, analyzes the prepared sample according to the selected assay. Data with respect to at least one of a result of the analysis and an identification of the prepared sample is communicated from the sample analysis system to the sample preparation system.

[0032] Disclosed herein is~~According to another embodiment of the present invention,~~ an automated sample preparation and analysis system that includes a sample analysis system and a sample preparation system. The sample analysis system includes a mass spectrometer and is configured to analyze a plurality of samples according to respective assays selected from a database containing a plurality of unique assays. The sample preparation system includes a controller for sequencing the samples for analysis by the sample analysis system. The sequence of the sample analysis is dependent on the order of arrival to the automated sample preparation and analysis system, the priority status of each sample, and at least one of a target time to result for a sample, a target time to result for a selected assay, a remaining target time to result for a selected assay, a number of samples on-board, the number of samples awaiting analysis in accordance with the same selected assay, or mass spectrometer reconfiguration necessary for selected assays that precede and follow a selected assay for a particular sample.

[0033] Disclosed herein is~~In accordance with another embodiment of the present invention,~~ an automated biological specimen preparation and mass spectrometry analysis system for analyzing a plurality of biological specimens according to a selected assay from a database containing a plurality of unique assays that includes a sample preparation system and a sample analysis system. The sample preparation system prepares samples taken from at least one of the plurality of biological specimens. The sample analysis system, with a mass spectrometer, quantifies one or more analytes for one or more prepared samples. A specimen dock receives a plurality of containers, each containing a respective biological specimen. A reagent station receives a plurality of containers containing a reagent liquid. A sample station transfers a predetermined biological specimen and one or more predetermined reagent liquids to a sample vessel. An analysis staging station stores one or more sample vessels, each is containing a respective prepared sample. A transport mechanism transfers the prepared samples from one of the sample vessels to the sample analysis system.

[0034] Disclosed herein is~~Still another embodiment of the present invention is directed to~~ a method of entering an idle state for a sample preparation and analysis system. The sample preparation and analysis system includes a sample preparation system and a sample analysis system. To enter the idle state, the sample preparation and analysis system receives an idle state command. A plurality of blank samples is prepared by the sample preparation system in accordance with an assay that is selected from a database containing a plurality of unique assays. The blank samples do not include a sample of a specimen. First and second ones of the plurality of blank samples are analyzed with the sample analysis system in accordance with the selected assay. Other ones of the plurality of blank samples are analyzed with the sample analysis system in accordance with the selected assay until a wake up command is received.

[0035] Disclosed herein is~~Another embodiment of the present invention is directed to~~ a method of entering a standby state for a sample preparation and analysis system. The sample preparation and analysis system includes a sample preparation system and a sample analysis system. To enter the standby state, the sample preparation and analysis system receives a standby state command. A standby sample is prepared by the sample preparation system in accordance with an assay that is selected from a database containing a plurality of unique assays and does not include a sample of a specimen. The standby sample is analyzed with the sample analysis system in

accordance with the selected assay. At least one component of the sample preparation and analysis system is then powered down. The at least one component is selected from a group comprising a chromatography column heater, a gas flow, a temperature of an ionization source of a mass spectrometer, at least one vacuum pump, at least one fluid pump, a robotic device, a pipette assembly, a mixing station, an incubation station, a matrix interference removal station, a cooling system, and a heating system.

[0036] The above and other embodimentsobjects and advantages of the present invention shall be made apparent from the accompanying drawings and the descriptions thereof.

BRIEF DESCRIPTION OF THE FIGURES

[0037] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the present invention. In the figures, corresponding or like numbers or characters indicate corresponding or like structures.

[0038] FIG. 1A is a perspective view of an automated sample preparation and analysis system in accordance with one embodiment of the present invention.

[0039] FIG. 1B is a perspective view of an automated sample preparation and analysis system in accordance with another embodiment of the present invention.

[0040] FIG. 2 is a diagrammatic view of the automated sample preparation and analysis system of FIG. 1A.

[0041] FIG. 3A is a top view of the automated sample preparation and analysis system of FIG. 1A and according to one embodiment of the present invention.

[0042] FIG. 3B is a top view of the automated sample preparation and analysis system of FIG. 1B and according to one embodiment of the present invention.

[0043] FIG. 3C is a side elevational view of the automated sample preparation and analysis system of FIG. 1A with the front cover removed.

[0044] FIG. 3D is a side elevational view of the automated sample preparation and analysis system of FIG. 1B with the front cover removed.