lead to contamination and/or premature mixing of reagents leading to erroneous results and making the assay complex in nature.

Some known phage based systems and methods can result in undesirable and/or inconsistent delivery of reagents into a closed system. For example, some known systems and methods deliver reagents into a sample to facilitate a reaction that can be optically detected. Inconsistent and/or inaccurate delivery of such reagents can result in undesirable variability associated with the light detection, potentially false readings or the like. Some known systems employ sealed reagent containers or "blister packs" to isolate the reagents and the sample until delivery of the reagents is desired. To facilitate delivery of reagents from a blister pack, some known systems include mechanisms, such as rollers, to expel the reagent. Other known systems include multiple puncturers to facilitate the rupture of a blister pack. Excessive "dead volume" (the volume within a blister pack after actuation that can contain the reagent), however, can result in inconsistent delivery times and/or amounts. Moreover, delivery mechanisms of known systems can produce undesired effects when the reagent is delivered (e.g., excessive splash or incomplete mixing). For example, if the reagent is delivered too fast, splashing or excessive wetting of a container wall can limit the effectiveness of the reagent. If the reagent is delivered too slowly, however, the mixing time may be long, thus resulting in a slower-developing reaction. Thus, many known systems do not accommodate delivery of reagents associated with a flash luminescence reaction. In addition to the above-described drawbacks regarding the use of phage-based methods, known methods do not employ automation or instrumentation for enabling a "walk away" bacteriophage identification system. For example, many known systems do not accommodate closed system handling and/or measurement of a signal that is produced by certain reporter molecules, such as for example, a flash luminescence reaction. Thus, known systems and methods require skilled personnel and intimate handling of the samples, which can increase the possibility of false positives or negatives.

Thus, a need exists for improved apparatus and methods for rapid, cost effective and facile detection and identification of bacterial species in clinical samples. In particular, a need exists for improved rupture structures, delivery paths, and methods for delivering reagents within such systems.

SUMMARY

Systems for detecting and/or identifying target cells (e.g., bacteria) using engineered vectors (including viral vectors) and/or transduction particles are described herein. Herein, an apparatus may include a housing and an actuator. The housing, which defines a reagent volume that can

receive a reagent container, can be removably coupled to a reaction chamber. A delivery portion of the housing defines a delivery path between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber. The delivery path includes a protrusion such that the delivery path has a discontinuous inner surface. The actuator can be moved to convey a reagent from the reagent container into the reaction chamber via the delivery path.

In one aspect, the present invention refers to an apparatus, comprising:

- a housing (741, 1741, 2741, 3741) configured to be removably coupled to a reaction chamber (732, 1732, 2732, 3732), the housing defining a reagent volume (742, 1742, 2742, 2744, 3742) configured to contain a reagent, the housing including a side wall (774, 2774) defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the side wall including a protrusion (776, 1776, 2776, 2778, 3776) within the delivery path; and
- an actuator (750, 1750, 2750, 2760, 3750) configured to be manipulated to convey the reagent from the reagent volume into the reaction chamber via the delivery path,

wherein:

- the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter; and
- the protrusion extends into the flow area a distance (HP) from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2.

In another aspect, the present invention refers to an apparatus, comprising:

- a housing (741, 1741, 2741, 3741) configured to be removably coupled to a reaction chamber (732, 1732, 2732, 3732), the housing defining a reagent volume (742, 1742, 2742, 2744, 3742) configured to contain a reagent, the housing including delivery portion (1770, 2770, 2772, 3770) having a side wall (774, 2774) and an end surface (745, 1745, 2745), the side wall defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the end surface defining an exit opening (746, 2746) through which an exit flow of the reagent is conveyed when exiting the delivery path; and
- an actuator (750, 1750, 2750, 2760, 3750) configured to be manipulated to produce the exit flow of the reagent, the delivery portion configured such that the exit flow of the reagent forms a plume that is detached from the end surface of the delivery portion,

wherein the side wall of the delivery portion defines a flow area along a path length within the delivery path, the flow area bounded by the side wall and being within a plane normal to a longitudinal center line of the delivery path, the delivery portion including a flow structure within the delivery path such that a shape of the flow area is discontinuous.

In yet another aspect, the present invention refers to a method, comprising:

- coupling a reagent module (710, 1710, 2710) to a sample container such that an end surface (745, 1745, 2745) of the reagent module covers a reaction chamber (732, 1732, 2732) defined by the sample container, the reaction chamber containing a sample, the reagent module including a housing (741, 1741, 2741, 3741) defining a reagent volume (742, 1742, 2742, 2744, 3742) containing a reagent, the housing including a side wall (774, 2774) defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the reagent module is coupled to the reaction chamber, the side wall including a protrusion (776, 1776, 2776, 2778, 3776) within the delivery path;
- disposing, after the coupling, at least a distal end portion of the sample container into an instrument (100, 2100); and
- actuating the instrument to:
  - produce a force on the reagent module to move at least the distal end portion of the sample container into a detection volume (2234) of the instrument; and
  - manipulate, when the distal end portion of the sample container is in the detection volume, the reagent module to convey the reagent from the reagent volume into the reaction chamber via the delivery path

wherein:

- the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter (D); and
- the protrusion extends into the flow area a distance from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2.

In one example an apparatus is provided comprising a housing configured to be removably coupled to a reaction chamber, the housing defining a reagent volume configured to contain a reagent, the housing including a side wall defining a delivery path between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the side wall including a protrusion within the delivery path; and an actuator configured to be manipulated to convey the reagent from the reagent volume into the reaction chamber via the delivery path. In

some examples, the housing includes an end surface defining an exit opening through which the reagent is conveyed when the reagent exits the delivery path into the reaction chamber; and the protrusion extends into the exit opening. In some examples, the delivery path defines a longitudinal center line and has a path length; and the protrusion includes an edge parallel to the longitudinal center line, the edge having a protrusion length of at least ten percent of the path length. In some examples, the delivery path defines a longitudinal center line and has a path length; and the protrusion includes an edge parallel to the longitudinal center line, the edge having a protrusion length of at least half of the path length. In some examples, the protrusion length is substantially equal to the path length. In some examples, a flow area of the delivery path has a diameter; and the protrusion extends into the flow area a distance from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2. In some examples, a flow area of the delivery path has a diameter and a path length, a ratio of the path length to the diameter being between about 2.5 and about 3.5. In some examples, the side wall includes a plurality of protrusions within the delivery path, the plurality of protrusions including the protrusion. In some examples, the delivery path defines a longitudinal center line; and the side wall includes a plurality of protrusions within the delivery path, the plurality of protrusions including the protrusion, the plurality of protrusions being equally spaced circumferentially about the longitudinal center line. In some examples, the actuator has a plunger portion and an engagement portion, the plunger portion disposed within the reagent volume, the engagement portion of the actuator configured to receive a force to move the plunger portion within the reagent volume. In some

examples, the apparatus further comprises a reagent container disposed within the reagent volume, the reagent container containing the reagent and including a frangible portion, the housing including a puncturer within the reagent volume, the puncturer having a sharp point configured to pierce the frangible portion of the reagent container, the plunger portion of the actuator configured to contact the reagent container such that the puncturer punctures the frangible portion of the reagent container to convey the reagent from the reagent volume into the reaction chamber via the delivery path. In some examples, the apparatus further comprises the reagent container disposed within the reagent volume, the reagent container containing the reagent formulated to react with a plurality of reporter molecules in a sample to enhance production of a signal. In some examples, the reagent is a first reagent, the apparatus further comprising the reagent container disposed within the reagent volume, the reagent container containing the first reagent formulated to react with a plurality of reporter molecules in a sample to enhance production of a signal; and the reaction chamber containing a second reagent formulated to react with the sample to limit production of the signal. In some examples, the second reagent is formulated to sterilize the sample.

In another example an apparatus is provided comprising a housing configured to be removably coupled to a reaction chamber, the housing defining a reagent volume configured to contain a reagent, the housing including delivery portion having a side wall and an end surface, the side wall defining a delivery path between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the end surface defining an exit opening through which an exit flow of the reagent is conveyed when exiting the delivery path; and an actuator configured to be manipulated to produce the exit flow of the reagent, the delivery portion configured such that the exit flow of the reagent forms a plume that is detached from the end surface of the delivery portion. In some examples, a flow area of the delivery path has a diameter; and the plume is characterized by a plume width, a ratio of the plume width to the diameter being less than about 4. In some examples, the side wall includes a flow structure within the delivery path, the flow structure positioned to contact the exit flow of the reagent. In some examples, the delivery path defines a longitudinal center line and has a path length; and the flow structure includes an edge parallel to the longitudinal center line, the edge having an edge length of at least half of the path length. In some examples, the side wall of the delivery portion defines a flow area along a path length within the delivery path, the delivery portion including a flow structure within the delivery path such that a shape of the flow area is discontinuous. In some examples, the side wall includes a plurality of

protrusions within the delivery path, the plurality of protrusions being equally spaced circumferentially about a longitudinal center line of the flow path.

In another example, a method is provided, said method comprising coupling a reagent module to a sample container such that an end surface of the reagent module covers a reaction chamber defined by the sample container, the reaction chamber containing a sample, the reagent module including a housing defining a reagent volume containing a reagent, the housing including a side wall defining a delivery path between the reagent volume and the reaction chamber when the reagent module is coupled to the reaction chamber, the side wall including a protrusion within the delivery path; disposing, after the coupling, at least a distal end portion of the sample container into an instrument; and actuating the instrument to produce a force on the reagent module to move at least the distal end portion of the sample container into a detection volume of the instrument; and manipulate, when the distal end portion of the sample container is in the detection volume, the reagent module to convey the reagent from the reagent volume into the reaction chamber via the delivery path. In some examples, the actuating the instrument to manipulate the reagent module includes moving an actuator within the reagent volume to produce a flow of the reagent within the delivery path, the flow forming an exit plume upon exiting the delivery path into the reaction chamber, the exit plume being detached from the end surface of the reagent module. In some examples, the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, the speed such that the flow of the reagent is laminar. In some examples, the reagent is a solution containing tridecanal; a flow area of the delivery path has a characteristic diameter; and the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, a viscosity of the solution, the characteristic diameter, and the speed being such that the flow of the reagent is laminar. In some examples, the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, the speed being between about 30 mm/sec and about 50 mm/sec. In some examples, the reagent volume includes a reagent container containing the reagent; the housing includes a puncturer within the reagent volume; and the actuating the instrument to manipulate the reagent module includes moving an actuator within the reagent volume to (1) urge a frangible portion of the reagent container into contact with the puncturer to pierce the frangible portion and (2) produce a flow of the reagent within the

delivery path. In some examples, the delivery path defines a longitudinal center line and has a path length; and the protrusion includes an edge parallel to the longitudinal center line, the edge having a protrusion length of at least half of the path length. In some examples, a flow area of the delivery path has a diameter; and the protrusion extends into the flow area a distance from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2. In some examples, the delivery path defines a longitudinal center line; and the side wall includes a plurality of protrusions within the delivery path, the plurality of protrusions including the protrusion, the plurality of protrusions being equally spaced circumferentially about the longitudinal center line. In some examples, the actuating the instrument further causes an optical detector of the instrument to receive, during the time period, a signal associated with a magnitude of light emission in the detection volume. In some examples, the actuating the instrument to manipulate the reagent module includes moving an actuator within the reagent volume to produce a flow rate of the reagent within the delivery path, the flow rate being between about 1.1 ml/sec and about 1.5 ml/sec.

In another example, a method includes coupling a reagent module to a sample container such that an end surface of the reagent module covers a reaction chamber defined by the sample container, the reaction chamber containing a sample, the reagent module including a housing defining a reagent volume containing a reagent, the housing including a side wall defining a delivery path between the reagent volume and the reaction chamber when the reagent module is coupled to the reaction chamber; disposing, after the coupling, at least a distal end portion of the sample container into an instrument; and actuating the instrument to: a) produce a force on the reagent module to move at least the distal end portion of the sample container into a detection volume of the instrument, and b) manipulate, when the distal end portion of the sample container is in the detection volume, the reagent module to convey the reagent from the reagent volume into the reaction chamber via the delivery path within a time period between about 0.2 seconds and about 0.3 seconds. In some examples, the actuating the instrument further causes an optical detector of the instrument to receive, during the time period, a signal associated with a magnitude of light emission in the detection volume. In some examples, the side wall includes a protrusion within the delivery path. In some examples, the delivery path defines a longitudinal center line and has a path length; and the protrusion includes an edge parallel to the longitudinal center line, the edge having a protrusion length of at least half of the path length. In some examples, the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the

longitudinal center line, the flow area of the delivery path having a diameter; and the protrusion extends into the flow area a distance from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2. In some examples, the delivery path defines a longitudinal center line; and the side wall includes a plurality of protrusions within the delivery path, the plurality of protrusions including the protrusion, the plurality of protrusions being equally spaced circumferentially about the longitudinal center line. In some examples, the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, the speed such that the flow of the reagent is laminar. In some examples, the actuating the instrument to manipulate the reagent module includes moving an actuator within the reagent volume to produce a flow of the reagent within the delivery path, the flow forming an exit plume upon exiting the delivery path into the reaction chamber, the exit plume being detached from the end surface of the reagent module. In some examples, the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, the speed being between about 30 mm/sec and about 50 mm/sec. In some examples, the actuating the instrument to manipulate the reagent module includes moving an actuator within the reagent volume to produce a flow rate of the reagent within the delivery path, the flow rate being between about 1.1 ml/sec and about 1.5 ml/sec. In some examples, the reagent volume includes a reagent container containing the reagent; the housing includes a puncturer within the reagent volume; and the actuating the instrument to manipulate the reagent module includes moving an actuator within the reagent volume to urge a frangible portion of the reagent container into contact with the puncturer to pierce the frangible portion and to produce a flow of the reagent within the delivery path.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 are schematic illustrations of a container assembly according to an embodiment, in a first configuration and a second configuration, respectively.

FIGS. 3-5 are schematic illustrations of a container assembly according to an embodiment, in a first configuration, second configuration, and third configuration, respectively.

FIG. 6 is a cross-sectional view of a portion of the container assembly shown in FIGS. 3-5 taken along the line X-X in FIG. 3.

FIGS. 7 and 8 show a perspective view and an exploded view, respectively, of a container assembly, according to an embodiment.

CLAIMS

1. An apparatus, comprising:
   - a housing (741, 1741, 2741, 3741) configured to be removably coupled to a reaction chamber (732, 1732, 2732, 3732), the housing defining a reagent volume (742, 1742, 2742, 2744, 3742) configured to contain a reagent, the housing including a side wall (774, 2774) defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the side wall including a protrusion (776, 1776, 2776, 2778, 3776) within the delivery path; and
   - an actuator (750, 1750, 2750, 2760, 3750) configured to be manipulated to convey the reagent from the reagent volume into the reaction chamber via the delivery path,

   wherein:
   - the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter; and
   - the protrusion extends into the flow area a distance (H_P) from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2.

2. The apparatus of claim 1, wherein the housing includes an end surface (745, 1745, 2745) defining an exit opening (746, 2746) through which the reagent is conveyed when the reagent exits the delivery path into the reaction chamber; and the protrusion extends into the exit opening.

3. The apparatus of any one of claims 1 or 2, wherein:
   - the delivery path defines a longitudinal center line (CL) and has a path length (L); and
   - the protrusion includes an edge (1761, 2762) parallel to the longitudinal center line, the edge having a protrusion length (L_P) of at least ten percent of the path length.

4. The apparatus of any one of claims 1 to 3, wherein:
   - the delivery path defines a longitudinal center line and has a path length; and
   - the protrusion includes an edge parallel to the longitudinal center line, the edge having a protrusion length of at least half of the path length.

5. The apparatus of claim 4, wherein the protrusion length is substantially equal to the path length.

6. The apparatus of any one of claims 1 to 5, wherein the delivery path defines a longitudinal center line, a path length, and a flow area, the path length being along the longitudinal center line, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter, a ratio of the path length to the diameter being between about 2.5 and about 3.5.

7. The apparatus of any one of claims 1 to 6, wherein the side wall includes a plurality of protrusions (1771, 2771, 2778) within the delivery path, the plurality of protrusions including the protrusion.

8. The apparatus of any one of claims 1 to 7, wherein:
   - the delivery path defines a longitudinal center line; and
   - the side wall includes a plurality of protrusions within the delivery path, the plurality of protrusions including the protrusion, the plurality of protrusions being equally spaced circumferentially about the longitudinal center line.

9. The apparatus of any one of claims 1 to 8, wherein the actuator has a plunger portion (1754, 2754, 2756) and an engagement portion (1752, 2752, 2753), the plunger portion disposed within the reagent volume, the engagement portion of the actuator configured to receive a force to move the plunger portion within the reagent volume.

10. The apparatus of claim 9, further comprising:
   - a reagent container (1780, 2780, 2790, 3780) disposed within the reagent volume, the reagent container containing the reagent and including a frangible portion (1788, 2788, 2789, 3788), the housing including a puncturer (1792, 2792, 2794, 3792) within the reagent volume, the puncturer having a sharp point configured to pierce the frangible portion of the reagent container; and
   - the plunger portion of the actuator configured to contact the reagent container such that the puncturer punctures the frangible portion of the reagent container to convey the reagent from the reagent volume into the reaction chamber via the delivery path.

11. The apparatus of claim 10, further comprising:
   - the reagent container disposed within the reagent volume, the reagent container containing the reagent formulated to react with a plurality of reporter molecules in a sample to enhance production of a signal.

12. The apparatus of claim 11, wherein the reagent is a first reagent, the apparatus further comprising:

- the reagent container disposed within the reagent volume, the reagent container containing the first reagent formulated to react with a plurality of reporter molecules in a sample to enhance production of a signal; and
- the reaction chamber containing a second reagent formulated to react with the sample to limit production of the signal.

13. The apparatus of claim 12, wherein the second reagent is formulated to sterilize the sample.

14. An apparatus, comprising:

- a housing (741, 1741, 2741, 3741) configured to be removably coupled to a reaction chamber (732, 1732, 2732, 3732), the housing defining a reagent volume (742, 1742, 2742, 2744, 3742) configured to contain a reagent, the housing including delivery portion (1770, 2770, 2772, 3770) having a side wall (774, 2774) and an end surface (745, 1745, 2745), the side wall defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the end surface defining an exit opening (746, 2746) through which an exit flow of the reagent is conveyed when exiting the delivery path; and
- an actuator (750, 1750, 2750, 2760, 3750) configured to be manipulated to produce the exit flow of the reagent, the delivery portion configured such that the exit flow of the reagent forms a plume that is detached from the end surface of the delivery portion,

wherein the side wall of the delivery portion defines a flow area along a path length within the delivery path, the flow area bounded by the side wall and being within a plane normal to a longitudinal center line of the delivery path, the delivery portion including a flow structure within the delivery path such that a shape of the flow area is discontinuous.

15. The apparatus of claim 14, wherein:

- the delivery path defines a longitudinal center line (CL) and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter (D); and

- the plume is characterized by a plume width, a ratio of the plume width to the diameter being less than about 4.

16. The apparatus of any one of claims 14 or 15, wherein the side wall including a flow structure (776, 1776, 2776, 2778, 3776) within the delivery path, the flow structure positioned to contact the exit flow of the reagent.

17. The apparatus of claim16, wherein:
- the delivery path defines a longitudinal center line and has a path length (L); and
- the flow structure includes an edge (1761, 2762) parallel to the longitudinal center line, the edge having an edge length (L_P) of at least half of the path length.

18. The apparatus of any one of claims 16 to 17, wherein the side wall includes a plurality of protrusions (1771, 2771, 2778) within the delivery path, the plurality of protrusions being equally spaced circumferentially about a longitudinal center line of the flow path.

19. A method, comprising:
- coupling a reagent module (710, 1710, 2710) to a sample container such that an end surface (745, 1745, 2745) of the reagent module covers a reaction chamber (732, 1732, 2732) defined by the sample container, the reaction chamber containing a sample, the reagent module including a housing (741, 1741, 2741, 3741) defining a reagent volume (742, 1742, 2742, 2744, 3742) containing a reagent, the housing including a side wall (774, 2774) defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the reagent module is coupled to the reaction chamber, the side wall including a protrusion (776, 1776, 2776, 2778, 3776) within the delivery path;
- disposing, after the coupling, at least a distal end portion of the sample container into an instrument (100, 2100); and
- actuating the instrument to:
  - produce a force on the reagent module to move at least the distal end portion of the sample container into a detection volume (2234) of the instrument; and
  - manipulate, when the distal end portion of the sample container is in the detection volume, the reagent module to convey the reagent from the reagent volume into the reaction chamber via the delivery path

wherein:

- the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter (D); and
- the protrusion extends into the flow area a distance from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2.

20. The method of claim 19, wherein the actuating the instrument to manipulate the reagent module includes moving an actuator (750, 1750, 2750, 2760, 3750) within the reagent volume to produce a flow of the reagent within the delivery path, the flow forming an exit plume upon exiting the delivery path into the reaction chamber, the exit plume being detached from the end surface of the reagent module.

21. The method of any one of claims 19 or 20, wherein the actuating the instrument to manipulate the reagent module includes moving an actuator (750, 1750, 2750, 2760, 3750) at a speed within the reagent volume to produce a flow of the reagent within the delivery path, the speed such that the flow of the reagent is laminar.

22. The method of any one of claims 19 to 21, wherein:
- the reagent is a solution containing tridecanal;
- the delivery path defines a longitudinal center line (CL) and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a characteristic diameter (D); and
- the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, a viscosity of the solution, the characteristic diameter, and the speed being such that the flow of the reagent is laminar.

23. The method of any one of claims 19 to 22, wherein the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, the speed being between about 30 mm/sec and about 50 mm/sec.

24. The method of any one of claims 19 to 23, wherein:
- the reagent volume includes a reagent container (1780, 2780, 2790, 3780) containing the reagent;

- the housing includes a puncturer (1792, 2792, 2794, 3792) within the reagent volume; and

the actuating the instrument to manipulate the reagent module includes moving an actuator within the reagent volume to urge a frangible portion (1788, 2788, 2789, 3788) of the reagent container into contact with the puncturer to pierce the frangible portion and to produce a flow of the reagent within the delivery path.

25. The method of any one of claims 19 to 24, wherein:

- the delivery path defines a longitudinal center line (CL) and has a path length (L); and
- the protrusion includes an edge (1761, 2762) parallel to the longitudinal center line, the edge having a protrusion length (L_P) of at least half of the path length.

26. The method of any one of claims 19 to 25, wherein:

- the delivery path defines a longitudinal center line; and
- the side wall includes a plurality of protrusions (1771, 2771, 2778) within the delivery path, the plurality of protrusions including the protrusion, the plurality of protrusions being equally spaced circumferentially about the longitudinal center line.