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INJECTION SYSTEM

Abstract

An injection system is provided. A fluid reservoir is operable to contain a fluid. The fluid reservoir has a reservoir width, and the fluid reservoir including an outlet opening that has an outlet width. The outlet width is greater than 20% of the reservoir width. An injection pump coupled to the fluid reservoir includes a passageway in fluid communication with the outlet opening such that the passageway is operable to receive the fluid from the fluid reservoir via the outlet opening. The injection pump is operable to dispense the fluid from the passageway through a pump outlet. T conduit in fluid communication with the injection pump forms a channel operable to receive the fluid dispensed from the passageway. The channel is operable to permit the fluid to flow therethrough. The passageway and the channel extend linearly along a longitudinal axis.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/556,145, filed in the U.S. Patent and Trademark Office on Feb. 21, 2024, which is incorporated herein by reference in its entirety for all purposes.

TECHNICAL FIELD
[0002] The present disclosure relates generally to systems and techniques for filling containers with fluid.
BACKGROUND
[0003] Since the legalization of hemp and related products in the USA many formants of consumption have arisen. Vaporization, edibles, and topicals are all delivery methods for ingestion. The creation of hemp and related concentrates have created a market for high potency products that can either be pyrolyzed or ingested which are particularly popular for medical and chronic pain patients. This market demand has created a supply chain struggling to supply products due to the difficult and often hard-to-package concentrate product that is sold by the gram.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0004] In order to describe the manner in which the above-recited and other advantages and features of the disclosure can be obtained, a more particular description of the principles briefly described above will be rendered by reference to specific embodiments thereof, which are illustrated in the appended drawings. Understand that these drawings depict only exemplary embodiments of the disclosure and are not, therefore, to be considered to be limiting of its scope, the principles herein are described and explained with additional specificity and detail through the use of the accompanying drawings in which:
[0005] FIG. **1**A is a perspective view of an example injection assembly;
[0006] FIG. **1**B is a perspective view of the injection assembly of FIG. **1**A;
[0007] FIG. **2** is a schematic diagram of a controller which may be employed as shown in FIGS. **1**A-**1**B;
[0008] FIG. **3**A illustrates a perspective view of a load cell component;
[0009] FIG. **3**B illustrates a front elevational view of the load cell component;
[0010] FIG. **3**C illustrates a perspective view of the load cell component;
[0011] FIG. **4** is a perspective view of an injection system;
[0012] FIG. **5**A is a cross-sectional view of the injection system, with the injection pump in a withdrawn configuration;
[0013] FIG. **5**B is a cross-sectional view of the injection system, with the injection pump in an extended configuration;
[0014] FIG. **5**C is a top perspective view of the injection system;
[0015] FIG. **5**D is a cross-sectional view of the injection of FIG. **5**C, taken along lines **5**D-**5**D;
[0016] FIG. **6** is a perspective view of a diagram of the injection system;
[0017] FIG. **7**A is an enlarged view of a tip and a conduit of the injection system;
[0018] FIG. **7**B is a side view of the tip; and
[0019] FIG. **8** is a flow chart of a method of pumping a fluid for filling containers.
DETAILED DESCRIPTION

[0020] Various embodiments of the disclosure are discussed in detail below. While specific implementations are discussed, it should be understood that this is done for illustration purposes only. A person skilled in the relevant art will recognize that other components and configurations may be used without departing from the spirit and scope of the disclosure. Additional features and advantages of the disclosure will be outlined in the description which follows, and in part will be obvious from the description, or can be learned by practice of the herein disclosed principles. It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. The description is not to be considered as limiting the scope of the embodiments described herein.
[0021] FIG. **1**A illustrates a perspective view of an example injection assembly **10**. In at least one example, the injection assembly **10** is used to dispense accurate amounts of fluid into a container **350**. Container **350** can be a special purpose jar or a commercially available jar. An injection system **100** can be configured to dispense fluids (e.g., resin, oil, and/or terpene fluids) stored in a reservoir **102** to container **350**. For example, an injection pump **400** can be operable to cause the fluid in the reservoir **102** to flow out of a tip **700** and into the container **350**. While the injection system **100** is operating, a load cell **300** can determine the total weight in real-time. A controller **200** can receive data (e.g., from the load cell **300**) indicative of the total weight and send a signal to stop the injection system **100** and/or send a signal to the injection system **100** to dispense an amount of the fluid. The controller **200** can be a PLC or Computer system with an interface. Additional details about the reservoir **102**, controller **200**, container **350**, load cell **300**, and injection pump **400** are given below with respect to the additional figures.
[0022] As illustrated in FIGS. **1**A and **1**B, the injection assembly **10** can have a base **11**. The base **11** can be sized to be placed on a tabletop (not shown). The base **11** in other implementations can be floor mounted. The base **11** can function as a balancing base in that the base **11** serves to balance the components and provide some stability as the various components move and/or operate. The controller **200** can be coupled with the base **11**. In other examples, the controller **200** can be wirelessly coupled to the components and separate from the assembly. The fluid reservoir **102** can be coupled to the base **11**. The fluid reservoir **102** can be omitted when the concentrate filling system **10** is implemented without a separate fluid filling component such as the injection pump **400**. The fluid reservoir **102** stores oils that can be added through the injection pump **400**. The fluid reservoir **102** can include one or more heating and/or cooling components to control the temperature of the oil in the fluid reservoir **102**.
[0023] The concentrate filling system **10** includes a load cell **300**. The load cell **300** can be operable to be zeroed using a container **350**. Container **350** can be filled by the injection pump **400** in a systematic way so that a density of the particles that are within the container **350** can be measured. The conveyor **400** can also be coupled to base **11**. The injection pump **400** can be coupled to the fluid reservoir **102**. In other examples, the injection pump **400** can be coupled directly to the base **11**. The fluid reservoir **102** is also fluidically coupled with the injection pump **400** such that fluid can flow from the fluid reservoir **102** to the injection pump **400** and thereby be dispensed from the injection pump **400** into the container **350**.
[0024] The solid loader **600** can also be coupled to the base **11**. By having all of the components coupled to the base **11**, the concentrate filling system **10** can be designed to be installed within an existing facility on a tabletop.
[0025] As illustrated in FIGS. **1**A and **1**B, in some examples, the injection system **100** can be positioned on a platform **12**. The platform **12** can receive and hold the injection system **100** in a raised position for easier access and control for the operator. In some examples, as illustrated in FIG. **1**A, the platform **12** can be moveable. For example, the platform **12** can include wheels so that the platform **12** and the injection system **100** can be easily moved to any desired location.
[0026] In at least one example, the injection assembly **10** can be designed and assembled prior to shipping. In another example, the load cell **300** can be separated and packaged together with, but

physically not assembled with the other components of the injection assembly **10**. Additionally, the controller **200** can be arranged to be mounted directly to the base **11** as shown. In other examples, the controller **200** can be mounted on a stand and/or located on the back side of the base **11**.

[0027] FIG. **2** is a block diagram of an exemplary controller **200**. Controller **200** is configured to perform processing of data and communicate with the injection system **100**. For example, the controller **200** can be operable to receive data from the load cell **300** indicative of the weight of the fluid and send a control signal to the injection system **100** to adjust the dispensing of the fluid. In some examples, the controller **200** is operable upon receiving indicative of a predetermined weight of the container, fluid, and particles the controller is operable to send a control signal to the conveyor and the injection pump to stop dispensing of fluid. In some examples, the controller **200** includes a display screen. The display screen can be operable to display information including the weight of the container **350** including the contents. Furthermore, the display information can include system settings, density, cycle time, fill settings, solid settings, and heat settings.

[0028] In operation, controller **200** communicates with one or more of the components discussed herein and may also be configured to communication with remote devices/systems.

[0029] As shown, controller **200** includes hardware and software components such as network interfaces **210**, at least one processor **220**, sensors **260** and a memory **240** interconnected by a system bus **250**. Network interface(s) **210** can include mechanical, electrical, and signaling circuitry for communicating data over communication links, which may include wired or wireless communication links. Network interfaces **210** are configured to transmit and/or receive data using a variety of different communication protocols, as will be understood by those skilled in the art.

[0030] Processor **220** represents a digital signal processor (e.g., a microprocessor, a microcontroller, or a fixed-logic processor, etc.) configured to execute instructions or logic to perform tasks for the injection assembly **10**. Processor **220** may include a general purpose processor, special-purpose processor (where software instructions are incorporated into the processor), a state machine, application specific integrated circuit (ASIC), a programmable gate array (PGA) including a field PGA, an individual component, a distributed group of processors, and the like. Processor **220** typically operates in conjunction with shared or dedicated hardware, including but not limited to, hardware capable of executing software and hardware. For example, processor **220** may include elements or logic adapted to execute software programs and manipulate data structures **245**, which may reside in memory **240**.

[0031] Sensors **260** typically operate in conjunction with processor **220** to perform measurements, and can include special-purpose processors, detectors, transmitters, receivers, and the like. In this fashion, sensors **260** may include hardware/software for generating, transmitting, receiving, detection, logging, and/or sampling parameters.

[0032] Memory **240** comprises a plurality of storage locations that are addressable by processor **220** for storing software programs and data structures **245** associated with the embodiments described herein. An operating system **242**, portions of which may be typically resident in memory **240** and executed by processor **220**, functionally organizes the device by, inter alia, invoking operations in support of software processes and/or services **244** executing on controller **200**. These software processes and/or services **244** may perform processing of data and communication with controller **200**, as described herein. Note that while process/service **244** is shown in centralized memory **240**, some examples provide for these processes/services to be operated in a distributed computing network.

[0033] It will be apparent to those skilled in the art that other processor and memory types, including various computer-readable media, may be used to store and execute program instructions pertaining to the fluid injection techniques described herein. Also, while the description illustrates various processes, it is expressly contemplated that various processes may be embodied as modules having portions of the process/service **244** encoded thereon. In this fashion, the program modules may be encoded in one or more tangible computer readable storage media for execution, such as with fixed logic or programmable logic (e.g., software/computer instructions executed by a processor, and any processor may be a programmable processor, programmable digital logic such as field programmable gate arrays or an ASIC that comprises fixed digital logic. In general, any process logic may be embodied in processor **220** or computer readable medium encoded with instructions for execution by processor **220** that, when executed by the processor, are operable to cause the processor to perform the functions described herein.

[0034] Additionally, the controller **200** can apply machine learning, such as a neural network or sequential logistic regression and the like, to determine relationships between the injection system **100** and the fluid. For example, a deep neural network may be trained in advance to capture the complex relationship between the injection pump **400**, the movement of the fluid from the reservoir **102** and out of the tip **700** into the container **350**. This neural net can then be deployed in the estimation of fluid injection. As such, the determination of the amount of fluid that is being dispensed can be more accurate.

[0035] FIG. **3**A illustrates a side elevational view of a load cell **300**. FIG. **3**B illustrates a front elevational view of a load cell **300**. The load cell **300** is operable to receive a container **350**. Container **350** receives the dispensed fluid from the injection system **100**. The load cell **300** can be configured with different attachment dies **320** designed to properly seat different containers on the load cell **300**. The attachment dies **320** can be secured to the load cell using an affixment device **330**. The attachment dies **320** allow for the container **350** to be quickly centered thereby allowing for accurate measurements by the load cell **300**. In at least one example, the affixment device **330** can be a screw that connects to the load cell **300**. Additionally, the load cell includes platform **310** and port **340**. Port **340** can be coupled to a cord that is operable to transfer data and/or power to the load cell **300** and/or from the load cell **300**. The platform **310** can be operable to receive the attachment dies **320** which allow for accurate centering of mass for weight measurement.

[0036] The load cell **300** is operable to move in response to one or more signals from the controller and take additional measurements and send additional measurement data to the controller, which is operable to determine a density of a mixture in the container. In at least one example the movement of the load cell **300** is a series of four strokes.

[0037] FIG. **3**C illustrates a prospective view of another load cell **300**. The load cell **300** includes a platform **322** to which different types of attachment dies **320** can be coupled thereto. In other examples, the platform **322** can be used directly to put a container **350** on. Dies can also be shaped to specific containers to allow for faster loading and unloading. In some examples, the containers can be shaped differently such as a square shape or hexagonal shape. In those examples, different shape dies can be implemented. Furthermore, some dies can be shaped that allow for a variety of different containers.

[0038] FIGS. **4**, **5**A, **5**B, **5**C, and **5**D illustrate the injection system **100** that is operable to dispense the fluid (e.g., resin, oil, and/or terpene fluid) into the container **350**.

[0039] As shown in FIGS. **4**-**5**D, the injection system **100** can include a fluid reservoir **102** operable to contain the fluid. The fluid is operable to be dispensed from the reservoir **102** by an injection pump **400** into a conduit **508** and out of the tip **700**.

[0040] The injection pump **400** is coupled to the fluid reservoir **102** such that the fluid flows into the injection pump **400** and is dispensed from the injection pump **400** out of a pump outlet **504** into the conduit **508**. In at least one example, the injection pump **400** can include a motor **402**, a housing **406**, and a piston **404**. The piston **404** can be at least partially received in the housing **406**, and the piston **404** can translate within the housing **406** along the longitudinal axis X-X.

[0041] As shown in FIGS. **5**A-**5**D, the fluid reservoir **102** includes a chamber **106** that receives and/or stores the fluid **108**. The fluid reservoir **102** (e.g., the chamber **106**) has a reservoir width **106**D. The reservoir width **106**D can span across the chamber **106** between the walls of the fluid reservoir **102**. In at least one example, the fluid reservoir **102** can include a heater to keep the fluid **108** (e.g., oil) above a desired temperature to assist with dispensing, as some of the oils used might be slow flow type oils that dispensing at room temperature would take a long time to dispense.

[0042] The fluid **108** in the fluid reservoir **102** passes from the chamber **106** to the injection pump **400** through an outlet opening **500**. For example, the injection pump **400** can include a passageway **502** in fluid communication with the outlet opening **500** such that the passageway **502** is operable to receive the fluid **108** from the fluid reservoir **102** (e.g., the chamber **106**) via the outlet opening **500**. In at least one example, the passageway **502** can be positioned below the outlet opening **500** along a vertical axis Y-Y that is transverse to the longitudinal axis X-X. Accordingly, the fluid **108** in the fluid reservoir **102** can drop into the passageway **502** through the outlet opening **500** with the help of gravity. In some examples, the fluid **108** can be deposited into the passageway **502** through the outlet opening **500** when a pressure is applied. In some examples, the fluid **108** can flow into the passageway **502** through the outlet opening **500** when a negative pressure is applied from the injection pump **400** (e.g., in the passageway **502**).

[0043] FIGS. **5**A-**5**D illustrates the outlet opening **500**. In some examples, the outlet opening **500** can be formed by outlet walls **5000**, **5002**. The outlet walls **5000**, **5002** can include two side walls **5002** that span between two longitudinal walls **5000**. In some examples, the outlet walls **5000**, **5002** can slope from the fluid reservoir **102** to the outlet opening **500** to funnel the material towards and into the outlet opening **500**. In some examples, the outlet walls **5000**, **5002** can be substantially in line with the walls of the fluid reservoir **102**. For example, the outlet walls **5000**, **5002** can mirror the shape of the fluid reservoir **102** but may be a different size.

[0044] Conventional reservoirs have openings that are small holes after the reservoir has been tapered down to a small point. This can cause inefficiencies when dispensing the fluid from the reservoir to the injection pump and out through the conduit. For example, the fluid contained in the conventional reservoir can form small skinny wells after the fluid flows out of the small hole of the reservoir. This creates a vacuum in the fluid. After some time, when the conventional injection pump tries to pull fluid from the reservoir, little to no fluid flows out of the conventional reservoir as the negative pressure formed by the injection pump **400** only pulls air through the vacuum of the small skinny wells.

[0045] In at least one example, as illustrated in FIGS. **5**A-**5**D, the outlet opening **500** can be substantially rectangular in shape. In some examples, the outlet opening **500** can be substantially circular, oval, square, triangular, etc. in shape. For example, the outlet opening **500** can have a shape that substantially matches the shape of the fluid reservoir **102**. Accordingly, the fluid **108** can flow out of the fluid reservoir **102** with more case, as the fluid **108** is not being compressed as much as a conventional reservoir.

[0046] The outlet opening **500** can have an outlet width 400 W. In at least one example, the outlet width 400 W can be greater than 20% of the reservoir width **106**D. In at least one example, the outlet width 400 W can be greater than **25**% of the reservoir width **106**D. In at least one example, the outlet width 400 W can be greater than 30% of the reservoir width **106**D. In at least one example, the outlet width 400 W can be greater than 40% of the reservoir width **106**D. In at least one example, the outlet width 400 W can be greater than 50% of the reservoir width **106**D. In some examples, the outlet width 400 W can be greater than 60% of the reservoir width **106**D. In some examples, the outlet width 400 W can be greater than 70% of the reservoir width **106**D. In some examples, the outlet width 400 W can be greater than 80% of the reservoir width **106**D. In some examples, the outlet width 400 W can be greater than 90% of the reservoir width **106**D. By having an outlet width 400 W that is larger, the fluid **108** can flow out of the chamber **106** of the fluid reservoir **102** with more case. Additionally, the presently disclosed injection system **100** prevents the formation of the skinny wells, as layers of the fluid **108** from the fluid reservoir **102** simply drop into the passageway **502** to be loaded for the injection pump **400** to dispense. This creates a more efficient and effective dispensing system of the fluid **108** through the injection system **100**. Additionally, the injection system **100** lessens the amount of splitting of the fluid **108** which allows for more predictability and consistency of the dosage of the fluid **108** being dispensed.

[0047] In at least one example, the shape of the outlet opening **500** can substantially match the shape of the fluid reservoir **102**, and the outlet width 400 D can be substantially similar (e.g., greater than 20%, 25%, 30%, 40%, 50%, 60%, 70%, 80%, or 90%) to the reservoir width **106**D. Accordingly, the fluid **108** is efficiently and effectively dispensed into the passageway **502** of the injection pump **400** from the fluid reservoir **102**.

[0048] In at least one example, the injection pump **400** can include a piston **404** that is operable to translate within the passageway **502** to dispense the fluid **108** that is received in the passageway **502**. The piston **404** can be operable to transition between an extended configuration and a withdrawn configuration. For example, as illustrated in FIG. **5**A, the piston **404** is shown in the withdrawn configuration where the piston **404** is not extended or is only just extended into the passageway **502**. FIG. **5**B illustrates the piston **404** in the extended configuration where the piston **404** is extended into the passageway **502**, for example towards and/or adjacent to the pump outlet **504**. When the piston **404** transitions from the withdrawn configuration to the extended configuration, the piston **404** is operable to push the fluid received in the passageway **502** out of the pump outlet **504**. When the piston **404** transitions from the extended configuration to the withdrawn configuration, the fluid flows from the fluid reservoir **102** through the outlet opening **500** into the passageway **502**. For example, when the piston **404** transitions from the extended configuration to the withdrawn configuration, a negative pressure in the passageway **502** can be created which draws the fluid **108** from the reservoir **102** into the passageway **502**. In some examples, when the piston **404** transitions from the extended configuration to the withdrawn configuration, the piston **404** is withdrawn from the passageway **502** which creates empty space in the passageway **502**. As the passageway **502** is positioned below the reservoir **102** along the vertical axis, gravity can help pull the fluid from the reservoir **102** into the passageway **502**. In at least one example, the piston **404** can be operable to translate along the longitudinal axis when transitioning between the extended configuration and the withdrawn configuration. In some examples, the piston **404** can be operable to translate along the longitudinal axis X-X on a same plane as the passageway **502** and the channel **506** of the conduit **508**.

[0049] The piston **404** translating along the longitudinal axis X-X on a same plane as the passageway **502** and the channel **506** of the conduit **508** allows for the fluid **108** to flow without excess pressure and force exerted onto the fluid **108**. The fluid **108** only drops into the passageway **502** through the outlet opening **500** along a vertical axis Y-Y, and then gets pushed out by the piston **404** to be dispensed from the tip **700** along the longitudinal axis X-X that is substantially perpendicular to the vertical axis Y-Y. The fluid **108** is not encountering any turns or angles which prevents less closing and/or splitting of the fluid **108**. Further, the amount of fluid **108** that is dispensed becomes more predictable and consistent, which provides for more accurate metering of the fluid **108** into the container **350**.

[0050] Additionally, as the outlet opening **500** has such a large size and/or a shape that corresponds with the shape of the fluid reservoir **102**, the fluid can more easily enter the passageway **502**. More fluid can then be dispensed easily with less clogging, splitting of the fluid **108**, and/or creation of wells in comparison to conventional injection systems.

[0051] In some examples, a pressure and/or a force may be applied to the fluid received in the fluid reservoir **102**. For example, a pressure and/or a physical force may be applied to the top of the fluid in the fluid reservoir **102** to push the fluid towards and into the outlet opening **500** into the passageway **502**. A physical force may include a lid or a barrier that covers the fluid that is lowered towards the outlet opening **500**. In some examples, the lid or barrier may cover substantially the entirety of the fluid (e.g., the entirety of the chamber **106**) so that the force applied is substantially evenly spread across the fluid.

[0052] In some examples, the injection pump **400** can be coupled with the controller **200** such that the controller **200** can control the amount of the fluid that is dispensed from the injection pump **400** and received in the container **350**. The injection pump **400** can be operable to dispense a predetermined amount of the fluid into the container **350**. For example, the injection system 4300 can be operable to dispense a predetermined amount of a total of 1 gram of the fluid into the container **350**. The controller **200** can set the injection pump **400** to dispense a first amount which can be substantially equal to the predetermined amount of 1 gram. In some examples, the first amount can be performed by one piston stroke. However, the injection pump **400** and/or the fluid may cause the amount of fluid dispensed from the injection pump **400** of the first amount to be substantially equal to the predetermined amount (e.g., 1 gram) but not equal. For example, the consistency of the fluid and/or bubbles in the fluid may lead to the first amount to be less than (e.g., 5%, 10%, 18%, etc. less than) the predetermined amount. The container **350** can then be set on the load cell **300** which can measure the first amount of the fluid in the container **350**. The controller **200** can receive the measurement of the first amount of the fluid in the container **350** and determine a second amount of the fluid to be dispensed into the container **350**. The second amount of the fluid can be based on a difference between the first amount of fluid in the container and the predetermined amount. In some examples, the second amount of the fluid can be 0 grams. In some examples, the second amount of the fluid can be the 5%, 10%, 18%, etc. amount of the predetermined amount (e.g., 1 gram) to make up for the amount of the first amount being less than the predetermined amount. The controller **200** can then set the injection pump **400** to dispense the second amount of the fluid into the container **350** so that the container **350** contains the entirety of the predetermined amount (e.g., 1 gram) of the fluid. The controller **200** can determine the settings for the injection pump **400** via the type of fluid, type of injection pump **400**, and/or other criteria so that the injection pump **400** dispenses the second amount of the fluid to have the container **350** receive the predetermined amount of the fluid.

[0053] The fluid then flows from the passageway **502** of the injection pump **400** through the pump outlet **504** into the conduit **508**. The conduit **508** forms a channel **506** operable to permit the fluid to flow therethrough. In at least one example, the conduit **508** can be directly coupled with the pump outlet **504** of the injection pump **400** such that the fluid flows directly from the pump outlet **504** of the injection pump **400** into the channel **506** of the conduit **508**.

[0054] As illustrated in FIGS. **5**A-**7**A, the conduit **508** extends linearly along a longitudinal axis X-X. For example, the conduit **508** can extend parallel with the longitudinal axis X-X. Accordingly, the channel **506** does not include a turn (e.g., a 90 degree turn). The channel **506** extending linearly along the longitudinal axis X-X (e.g., without a turn) allows the fluid to flow through the channel **506** without separation of the solid(s) and liquid(s) in the fluid. For example, if the channel included turns as with conventional injection systems, the solid(s) in the fluid may remain in the turn while the liquid(s) move forward through the channel **506** to be dispensed. This can affect the concentration of the fluid and cause the fluid that is received in the container **350** to be undeliverable and unusable due to regulation criteria. For example, when the fluid includes hash resin, the resin that is deposited must be a certain concentration. If the resin is separated, then the product is undeliverable as the separation strips the resin of THC. The concentration is then unpredictable and/or lower than the product should be, even though the correct volume has been deposited into the container **350**.

[0055] In at least one example, as shown in FIGS. **5**A, **5**B, and **6**, the passageway **502** and the channel **506** extend linearly along the longitudinal axis X-X. In some examples, the passageway **502** and the channel **506** extend linearly along the longitudinal axis X-X on a same plane. Accordingly, the fluid is operable to flow from the passageway **502** into and through the channel **506** without a turn. This allows the fluid to flow through the injection pump **400** (e.g., through the passageway **502**) and into the channel **506** without separation of the solid(s) and liquid(s) in the fluid. Additionally, this can allow for less blockage and more efficient and effective performance of the injection pump **400** with the piston **404** extending longitudinally to push the fluid along the longitudinal axis X-X to dispense the fluid.

[0056] In at least one example, the injection system **100** also includes the tip **700** that is operable to dispense the fluid into the container **350**. The tip **700** can be coupled with the conduit **508** such that the fluid can flow from the conduit **508** directly into the tip **700**. In at least one example, the tip **700** can be detachably coupled with the conduit **508** for easy replacement and/or cleaning. The fluid can then flow out of the tip **700** to be dispensed into the container **350**. In at least one example, the tip **700** can include a needle. In some examples, the tip **700** can include a pipette tip.

[0057] As illustrated in FIGS. **5**A-**7**B, the tip **700** can also extend along the longitudinal axis X-X. In some examples, similar to the conduit **508**, the tip **700** does not include a turn (e.g., a 90 degree turn). In some examples, the tip **700** can extend linearly along the longitudinal axis X-X on the same plane as the passageway **502** and the channel **506**. The tip **700** extending linearly along the longitudinal axis X-X (e.g., without a turn) on the same plane allows the fluid to flow through the tip **700** without separation of the solid(s) and liquid(s) in the fluid. For example, if the channel included turns, the solid(s) in the fluid may remain in the turn while the liquid(s) move forward through the tip **700** to be dispensed into the container **350**. Moreover, the fluid does not encounter any turns as the fluid flows from the channel **506** of the conduit **508** into and through the tip **700**. This further improves the fluid properties, as the fluid is less likely to separate if at all.

[0058] As illustrated in FIG. **7**A, in at least one example, the tip **700** can include tip walls **704** that form a tip channel **706**. The tip channel **706** can be operable to receive the fluid from the channel 4320 of the conduit **508** such that the fluid can flow through the tip channel **706** out of an exit opening **702** through which the fluid is dispensed.

[0059] In at least one example, while the tip channel **706** and the tip **700** extend along the longitudinal axis X-X, the tip walls **704** can taper towards the exit opening **702**. For example, the tip **700** can have substantially a conical or a frustoconical shape (not considering the exit opening **702**). In some examples, the tip **700** can have substantially a pyramidal shape. In some examples, the tip walls **704** can taper at a taper angle **600**A in relation to the longitudinal axis X-X. While FIG. **7**A illustrates the taper angle **600**A being in relation to the conduit walls **512**, the conduit **512** walls are parallel to the longitudinal axis X-X, so the taper angle **600**A is also equivalently tapered in relation to the longitudinal axis X-X.

[0060] In at least one example, the tip walls **704** can taper at the taper angle **600**A in relation to the longitudinal axis X-X that is greater than about 135 degrees. In some examples, the taper angle **600**A can be equal to or less than about 180 degrees. In some examples, the taper angle **600**A can be between about 135 degrees and about 180 degrees. In some examples, the taper angle **600**A can be between about 145 degrees and about 180 degrees. In some examples, the taper angle **600**A can be between about 155 degrees and about 180 degrees. In some examples, the taper angle **600**A can be between about 165 degrees and about 180 degrees. In some examples, the taper angle **600**A can be between about 175 degrees and about 180 degrees. Accordingly, the linear pathway provided by the conduit **508** and the tip **700** does not contract at a steep angle (e.g., between 135 degrees and 90 degrees). By having a gradual taper of the tip **700** with the taper angle **600**A, the injection system **500** can be depressurized. If the taper angle **600**A was steeper, the injection system **500** can be pressurized and cause separation. For example, with a stepper taper angle **600**A, the fluid would be pushed against the taper walls **704** which creates pressure on the fluid as the fluid slides down the taper walls **704** towards the exit opening **702**. The pressure on the fluid can cause the fluid to separate, and at least a portion of the solid(s) may remain on the taper walls **704** while the liquid(s) may flow out of the exit opening **702** to be disposed into the container **350**. This can affect the concentration of the fluid and cause the fluid that is received in the container **350** to be undeliverable and unusable due to regulation criteria.

[0061] In some examples, the tip walls **704** may not taper, and extend substantially parallel with the longitudinal axis X-X (e.g., a taper angle **600**A of about 180 degrees). Accordingly, the tip walls **704** may continue in parallel with the conduit walls **512**.

[0062] In at least one example, at least a portion of the tip **700** can be made of plastic. For example, at least a portion of the tip **700** can be made of low density polyethylene and/or polypropylene. In at least one example, the tip **700** can be operable to be cut to form the exit opening **702** through which the fluid is dispensed. By being able to cut the tip **700**, the desired size and/or shape of the exit opening **702** can be formed. For example, as shown in FIG. **7**A, the exit opening **702** can extend at an exit angle **702**A that is greater than 90 degrees in relation to the longitudinal axis X-X. In some examples, the exit angle **702**A can be between about 90 degrees and about 180 degrees. In some examples, the exit angle **702**A can be between about 95 degrees and about 180 degrees. In some examples, the exit angle **702**A can be between about 120 degrees and about 180 degrees. In some examples, the exit angle **702**A can be between about 150 degrees and about 180 degrees.

[0063] With such an exit angle **702**A for the exit opening **702**, the fluid can flow easily out of the exit opening **702** to be received in the container **350**. Additionally, in some examples, the fluid may need to be scraped into the container **350**. With such an exit angle **702**A, the fluid can be easily scraped into the container **350** while preventing excess dripping of the fluid. For example, the container **350** may be raised to the exit opening **702** of the tip **700** for dispensing of the fluid into the container **350**. Once the injection pump **400** finishes pumping the desired amount of fluid, the fluid at the exit opening **702** of the tip **700** can be scraped off and deposited into the container **350**. The amount of the fluid that is dispensed and received in the container **350** is as desired.

[0064] In at least one example, the tip **700** being at least partially made of plastic allows the tip **700** to be cut to obtain the desired size and shape of the exit opening **702**. For example, if the exit opening **702** is too large, the fluid may drip out of the tip **700**. If the exit opening **702** is too small, the fluid may not flow out of the tip **700** via the exit opening **702**, which can lead to pressure buildup and subsequently separation of the fluid. Accordingly, the tip **700** is a variable size nozzle that can be cut and manipulated as fit for the fluid, the container **350**, and/or the injection pump **400**.

[0065] In at least one example, the tip **700** can be detachably coupled with the conduit **508**. Accordingly, the tip **700** can be replaceable which can improve ease of maintenance. In some examples, the tip **700** being detachably coupled can assist with ensuring that the exit opening **702** is the desired and appropriate size. For example, if the exit opening **702** that is cut is not as desired, the tip **700** can be detached and discarded, and a new tip **700** can be attached to the conduit **508**.

[0066] As illustrated in FIG. **7**B, the tip **700** may not taper the entire length **700**L of the tip **700**. The tip **700** may have a parallel portion where the walls **701** extend substantially parallel to one another then a taper portion where the walls **704** taper towards the exit opening **702**. In at least one example, the parallel portion can be proximate the conduit **508** and be between the conduit **508** and the taper portion. In at least one example, the parallel portion can have a width **700**D between about 7 millimeters and about 21 millimeters. In some examples, the parallel portion can have a width **700**D between about 11 millimeters and about 18 millimeters. In some examples, the parallel portion can have a width **700**D between about 13 millimeters and about 15 millimeters. In some examples, the parallel portion can have a width **700**D about 14 millimeters. Having a wide opening into the parallel portion can allow for an easier transition for the fluid to flow from the conduit **508** into the tip **700**. In some examples, the tip **700** can have a length **700**L between about 45 millimeters and about 80 millimeters. In some examples, the tip **700** can have a length **700**L between about 55 millimeters and about 75 millimeters. In some examples, the tip **700** can have a length **700**L between about 60 millimeters and about 70 millimeters. In some examples, the tip **700** can have a length **700**L between about 64 millimeters and about 66 millimeters. In some examples, the tip **700** can have a length **700**L about 46.50 millimeters.

[0067] Referring to FIG. **8**, a flowchart is presented in accordance with an example embodiment. The method **800** is provided by way of example, as there are a variety of ways to carry out the method. The method **800** described below can be carried out using the configurations illustrated in FIGS. **1**A-**7**B, for example, and various elements of these figures are referenced in explaining example method **800**. Each block shown in FIG. **8** represents one or more processes, methods, or subroutines, carried out in the example method **800**. Furthermore, the illustrated order of blocks is

illustrative only and the order of the blocks can change according to the present disclosure. Additional blocks may be added or fewer blocks may be utilized, without departing from this disclosure. The example method **800** can begin at block **802**.
[0068] At block **802**, fluid is received from a fluid reservoir through an outlet opening in a passageway of an injection pump. The outlet opening has an outlet width that is greater than 20% of a reservoir width.
[0069] At block **804**, the injection pump pumps the fluid from the passageway into a conduit. The passageway and the conduit extend linearly along a longitudinal axis. In at least one example, the passageway and a channel for the conduit can extend along the longitudinal axis on a same plane. The channel can be formed in the conduit to permit fluid to pass therethrough.
[0070] In at least one example, to pump the fluid, a piston of the injection pump can be transitioned between an extended configuration and a withdrawn configuration. When the piston transitions from the withdrawn configuration to the extended configuration, the piston is operable to push the fluid received in the passageway out of the pump outlet. When the piston transitions from the extended configuration to the withdrawn configuration, the fluid flows from the fluid reservoir through the outlet opening into the passageway. In at least one example, the piston can translate along the longitudinal axis. In some examples, the piston can translate along the longitudinal axis on the same plane as the passageway and the channel.
[0071] At block **806**, the fluid flows through the conduit to be dispensed into a container.
[0072] In at least one example, a tip can be detachably coupled with the conduit. The tip can extend linearly along the longitudinal axis. In at least one example, the tip extends along the longitudinal axis on a same plane as the passageway and the channel.
[0073] While the above example shows implementation with a single fluid reservoir **102**, controller **200**, container **350**, load cell **300**, and injection pump **400**, the present technology can be implemented with a plurality of fluid reservoirs, controllers, containers, load cells, and/or injection pumps.
[0074] While examples of the present inventive concept have been shown and described herein, it will be obvious to those skilled in the art that such examples are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the disclosure. It should be understood that various alternatives to the examples of the disclosure described herein can be employed in practicing the disclosure. It is intended that the following claims define the scope of the disclosure and that methods and structures within the scope of these claims and their equivalents be covered thereby.

Claims

1. An injection system comprising: a fluid reservoir operable to contain a fluid, the fluid reservoir having a reservoir width, the fluid reservoir including an outlet opening that has an outlet width, the outlet width being greater than 20% of the reservoir width; an injection pump coupled to the fluid reservoir, the injection pump including a passageway in fluid communication with the outlet opening such that the passageway is operable to receive the fluid from the fluid reservoir via the outlet opening, the injection pump operable to dispense the fluid from the passageway through a pump outlet; a conduit in fluid communication with the injection pump, the conduit forming a channel operable to receive the fluid dispensed from the passageway, the channel operable to permit the fluid to flow therethrough, wherein the passageway and the channel extend linearly along a longitudinal axis.
2. The injection system of claim 1, wherein the passageway and the channel extend along the longitudinal axis on a same plane.
3. The injection system of claim 1, wherein the passageway is positioned below the outlet opening along a vertical axis.

4. The injection system of claim 1, wherein the conduit is directly coupled with the pump outlet of the injection pump.
5. The injection system of claim 1, wherein fluid is operable to flow from the passageway into and through the channel without a turn.
6. The injection system of claim 1, wherein the outlet width is greater than 80% of the reservoir width.
7. The injection system of claim 1, further comprising a tip coupled with the conduit such that the fluid flows out of the tip to be dispensed into a container.
8. The injection system of claim 7, wherein the tip is detachably coupled with the conduit.
9. The injection system of claim 7, wherein the tip extends linearly along the longitudinal axis.
10. The injection system of claim 9, wherein the tip extends along the longitudinal axis on a same plane as the passageway and the channel.
11. The injection system of claim 1, wherein the injection pump includes a piston that is operable to translate within the passageway to dispense the fluid.
12. The injection system of claim 11, wherein the piston transitions between an extended configuration and a withdrawn configuration, wherein when the piston transitions from the withdrawn configuration to the extended configuration, the piston is operable to push the fluid received in the passageway out of the pump outlet.
13. The injection system of claim 12, wherein when the piston transitions from the extended configuration to the withdrawn configuration, the fluid flows from the fluid reservoir through the outlet opening into the passageway.
14. A method comprising: receiving, from a fluid reservoir through an outlet opening, a fluid in a passageway of an injection pump; pumping, via the injection pump, the fluid from the passageway into a conduit; flowing the fluid through the conduit to be dispensed into a container, wherein the passageway and the conduit extend linearly along a longitudinal axis, wherein the outlet opening has an outlet width that is greater than 20% of a reservoir width.
15. The method of claim 14, wherein the passageway and a channel for the conduit extend along the longitudinal axis on a same plane.
16. The method of claim 14, wherein the pumping of the fluid includes: transitioning a piston of the injection pump between an extended configuration and a withdrawn configuration.
17. The method of claim 16, wherein when the piston transitions from the withdrawn configuration to the extended configuration, the piston is operable to push the fluid received in the passageway out of the pump outlet.
18. The method of claim 16, wherein when the piston transitions from the extended configuration to the withdrawn configuration, the fluid flows from the fluid reservoir through the outlet opening into the passageway.
19. The method of claim 14, further comprising: detachably coupling a tip with the conduit, wherein the tip extends linearly along the longitudinal axis.
20. The method of claim 19, wherein the tip extends along the longitudinal axis on a same plane as the passageway and a channel.