

HUMIDITY CONTROL IN CHEMICAL REACTORS

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application Serial No. 61/719,085, filed October 26, 2012, and entitled "Humidity Control in Chemical Reactors"; U.S. Provisional Patent Application Serial No. 61/869,118 filed August 23, 2013, and entitled "Humidity Control in Chemical Reactors"; and European Application No. 13306464.2 filed October 23, 2013 and entitled "Humidity Control in Chemical Reactors," each of which is incorporated herein by reference in its entirety for all purposes.

TECHNICAL FIELD

Systems and methods for the control of humidity in chemical reactors are generally described.

BACKGROUND

There is currently a great deal of interest in developing small volume bioreactors for growing cells, for example, for biopharmaceutical production. Controlling liquid levels in such reactors can be challenging. For example, evaporation of small amounts of liquid medium within the reactor can lead to relatively large changes in volume, which can adversely impact bioreactor operation. Improved systems and methods for controlling humidity in such chemical reactors are therefore desirable.

SUMMARY

Control of humidity in chemical reactors, as well as associated systems and methods, are generally described. Certain ~~embodiments~~ examples relate to the control of humidity within gas transport conduits. The subject matter of the present ~~invention~~ disclosure involves, in some cases, interrelated products, alternative solutions to a particular problem, and/or a plurality of different uses of one or more systems and/or articles.

In certain ~~embodiments~~ examples, a reactor system is ~~provided~~ disclosed. ~~In some embodiments, the~~ In some aspect, the present invention refers to a reactor system comprising a reactor chamber; a reactor chamber gas inlet conduit configured

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to transport gas into the reactor chamber through a reactor chamber gas inlet; a flow control mechanism configured to regulate the flow of gas through the reactor

chamber gas inlet conduit at a rate of equal to or less than about 1 milliliter per second; and a humidifier configured to humidify the gas transported through the reactor chamber gas inlet conduit, the humidifier positioned between the flow control mechanism and the reactor chamber gas inlet.

5 | ~~In some embodiments, the~~ another aspect, the present invention refers to a reactor
system ~~comprises~~ comprising a reactor chamber; a reactor chamber gas outlet conduit
configured to transport gas out of the reactor chamber through a reactor chamber gas
outlet; a flow control mechanism configured to regulate the flow of gas through the
reactor chamber gas outlet conduit at a rate of equal to or less than about 1 milliliter per
10 | second; and a liquid trap configured to remove liquid vapor from the gas within the
reactor chamber gas outlet conduit, the liquid trap positioned between the flow control
mechanism and the reactor chamber gas outlet.

| The reactor system comprises, in certain ~~embodiments~~ examples, a reactor
chamber, comprising a liquid sub-chamber configured to contain a liquid growth
15 | medium including at least one biological cell; a gas sub-chamber configured to contain a
gaseous headspace above the liquid growth medium; and a gas-permeable flexible
membrane separating the liquid sub-chamber from the gas sub-chamber. In certain
~~embodiments~~ examples, the reactor system comprises a gas inlet conduit configured to
transport gas into the gas sub-chamber; a gas outlet conduit configured to transport gas
20 | out of the gas sub-chamber; and a gas bypass conduit external to the reactor chamber,
connecting the gas inlet conduit to the gas outlet conduit.

| In yet another aspect, the present invention refers to a reactor system, comprising:
a reactor chamber, comprising: a liquid sub-chamber configured to contain a liquid
growth medium including at least one biological cell; a gas sub-chamber configured to
25 | contain a gaseous headspace above the liquid growth medium; and a gas-permeable
flexible membrane separating the liquid sub-chamber from the gas sub-chamber; a gas
inlet conduit configured to transport gas into the gas sub-chamber; a gas outlet conduit
configured to transport gas out of the gas sub-chamber; and a gas bypass conduit external
to the reactor chamber, connecting the gas inlet conduit to the gas outlet conduit.

30 | In a further aspect, the present invention refers to a method of operating a reactor,
comprising:
providing a reactor chamber, comprising: a liquid sub-chamber configured to contain a
liquid growth medium including at least one biological cell; a gas sub-chamber

configured to contain a gaseous headspace above the liquid growth medium; and a flexible membrane separating the liquid sub-chamber from the gas sub-chamber; transporting a gas from a gas source through a gas inlet conduit to the gas sub-chamber to deform the gas-permeable flexible membrane such that liquid is at least partially removed from the liquid sub-chamber; reducing the supply of the gas to the gas sub-chamber such that the flexible membrane returns toward its original position; transporting gas from the gas source through a gas bypass connected to the gas inlet conduit and external to the reactor chamber to remove liquid from the gas inlet conduit; and supplying gas from the gas source to the gas sub-chamber at least a second time to deform the gas-permeable flexible membrane such that liquid is at least partially evacuated from the liquid sub-chamber.

Certain ~~embodiments~~ examples relate to methods of operating a reactor. In certain ~~embodiments~~ examples, the method comprises providing a reactor chamber, comprising a liquid sub-chamber configured to contain a liquid growth medium including at least one biological cell; a gas sub-chamber configured to contain a gaseous headspace above the liquid growth medium; and a flexible membrane separating the liquid sub-chamber from the gas sub-chamber. In some ~~embodiments~~ examples, the method comprises transporting a gas from a gas source through a gas inlet conduit to the gas sub-chamber to deform the gas-permeable flexible membrane such that liquid is at least partially removed from the liquid sub-chamber; reducing the supply of the gas to the gas sub-chamber such that the flexible membrane returns toward its original position; transporting gas from the gas source through a gas bypass connected to the gas inlet conduit and external to the reactor chamber to remove liquid from the gas inlet conduit; and supplying gas from the gas source to the gas sub-chamber at least a second time to deform the gas-permeable