

CLAIMS

1. A device comprising an optical apparatus for monitoring bacterial growth of a drug-dosed liquid biological sample, the device comprising:
- 5 a sample container port for receiving a sample container, in use, the sample container having at least one detection chamber for containing the drug-dosed sample; and the optical apparatus comprising:
- a light source configured to emit light along an incident beam axis that, in use, intersects with at least one detection chamber of the sample container, and to illuminate the
- 10 drug-dosed sample contained within the detection chamber;
- a first photodetector configured to receive light scattered by bacteria in the sample;
- a light collection arrangement configured to:
- collect light exiting the detection chamber that has been scattered in a
- 15 forward direction by bacteria in the sample, in a range of scattering angles between about ± 4 and ± 20 degrees relative to the incident beam axis, and to direct the collected scattered light to the first photodetector; and
- prevent non-scattered light travelling parallel to the incident beam axis and exiting the detection chamber from reaching the first photodetector; and
- 20 at least one processor configured to:
- measure an intensity of the scattered light received by the first photodetector;
- determine a corresponding representative amount or concentration of bacteria present in the sample based on the intensity of the scattered light;
- 25 repeat the measuring and determining steps at a series of pre-determined intervals to determine changes in the representative amount or concentration of bacteria present in the sample as a function of time; and
- determine a corresponding susceptibility of the bacteria in the sample to the respective drug.
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2. The device of claim 1, wherein only light collected in the angular range between about ± 4 and ± 20 degrees relative to the incident beam axis is directed to and received by the first photodetector.
- 35 3. The device of claim 1 or claim 2, wherein the range of scattering angles of collected scattered light is between $+4$ and $+16$ degrees and -4 and -16 degrees relative to the incident beam axis.

4. The device of any preceding claim, wherein the light collection arrangement comprises:

5 (i) a concave elliptical reflector configured to collect and reflect only light in the angular range between about ± 4 and ± 20 degrees relative to the incident beam axis towards the first photodetector so that it is received by the first photodetector; or

10 (ii) a concave elliptical reflector configured to collect and reflect forward-scattered light in the angular range between about ± 4 and ± 20 degrees relative to the incident beam axis towards a condenser, the condenser arranged to receive light reflected by the concave elliptical reflector and to focus the received light onto the first photodetector.

5. The device of any preceding claim, wherein the light collection arrangement comprises a concave elliptical reflector shaped to reflect the forward-scattered light from the sample to the first photodetector or condenser, and wherein the concave elliptical reflector comprises an
15 aperture aligned with the incident beam axis and configured to allow non-scattered light from the detection chamber to pass through the concave elliptical reflector.

6. The device of any preceding claim, wherein the optical apparatus further comprises a second photodetector arranged to receive non-scattered light; optionally wherein the second
20 photodetector is positioned on the opposite side of the light collection arrangement to the sample, and aligned with the incident beam axis to receive the non-scattered light.

7. The device of any of claims 1 to 3, wherein the light collection arrangement comprises first and second condensing lenses and a mirror, wherein:

25 the first condensing lens is configured to direct the scattered light to the second condensing lens, and to focus non-scattered light travelling along the incident beam axis onto the mirror; and

the second condensing lens is configured to receive the scattered light from the first condensing lens and to focus the scattered light onto the first photodetector;

30 wherein the mirror is arranged along the incident beam axis between the first and second condensing lenses and is configured to reflect the non-scattered light away from the first photodetector.

8. The device of claim 7, wherein the mirror is arranged to reflect the non-scattered light
35 towards a second photodetector, the second photodetector configured to receive the non-scattered light from the mirror.

9. The device of any preceding claim, comprising a sample container carousel arranged inside the sample container port for engaging a sample container and configured to bring a detection chamber containing at least a portion of the biological sample in the sample container into alignment with the incident beam axis of the light source of the optical apparatus.

10. The device of claim 9, which comprises a motor operably coupled to the sample container carousel and configured to rotate the carousel to periodically bring a detection chamber containing at least a portion of the biological sample into and out of alignment with the incident beam axis of the light source.

11. The device of claim 9 or claim 10, wherein the sample container carousel is configured to engage a sample container comprising a plurality of detection chambers, and the sample container carousel is configured to rotate so as to bring each of the plurality of detection chambers of the sample container sequentially into and out of alignment with the incident beam axis of the light source.

12. The device of any of claims 9 to 11, wherein the sample container carousel comprises one or more openings configured to align with the one or plurality of detection chambers of the sample container when the sample container is correctly engaged with the sample container carousel in use.

13. The device of any of claims 9 to 12, wherein the sample container carousel includes one or more detectable calibration features for determining the position and/or orientation of the sample container carousel relative to the incident beam axis of the light source.

14. The device of claim 13, which comprises a calibration feature reader communicating with a processor of the device, in use, for determining a time interval between detection of a calibration feature by the calibration feature reader and an associated detection chamber coming into alignment with the incident beam axis of the light source.

15. The device of claim 14, wherein a processor of the optical apparatus:
(i) communicates with the first photodetector to measure the intensity of the scattered light received by the first photodetector during a predetermined time window corresponding to the time period during which a detection chamber of the sample container is in alignment with the incident beam axis of the light source; or

(ii) adjusts the length of the pre-determined intervals based on the detection of the or each calibration feature.

16. The device of any preceding claim, wherein the processor of the optical apparatus is
5 programmed to repeat the steps of measuring an intensity of the scattered light received by the first photodetector and determining a corresponding representative amount or concentration of bacteria present in the sample as a function of time periodically over a time period of: between about 20 minutes and about 2 hours, between about 20 minutes and about 1.5 hours, between about 20 minutes and about 1 hour or between about 30 minutes and
10 about 1 hour.

17. The device of any preceding claim, further comprising a temperature control system for controlling the temperature of air inside the device.

18. The device of claim 17, comprising at least one heating element and, optionally at least one air flow regulator arranged, in use, to bring warm air into contact with a sample container received inside the sample container port of the device, so as to maintain a biological sample within a detection chamber at a desired temperature.

19. The device of claim 17 or claim 18, comprising a pair of heating elements, each heating element operably associated with a fan to push warmed air towards the sample container port, in use to heat a sample within a detection chamber of a sample container received within the sample container port of the device.

20. The device of any preceding claim, wherein the light source of the optical apparatus is a laser light source, for example between 620 nm and 780 nm.

21. The device of any preceding claim, wherein the pre-determined intervals correspond to about 0.6 seconds at a rotational speed of 100 rpm.

22. The device of any preceding claim, wherein the processor of the optical apparatus is configured to identify a plurality of periodically occurring peak features in the measured light intensity, and to carry out the measuring and determining steps only between adjacent peak features.

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23. A system for monitoring bacterial growth of a drug-dosed liquid biological sample, the system comprising:

the device as defined in any of the preceding claims; and

a sample container comprising a plurality of detection chambers, each

5 detection chamber configured to contain a drug-dosed liquid biological sample;

wherein the system further comprises:

a sample positioning mechanism configured to align each of the plurality of

detection chambers in turn with the incident beam axis such that the light source

illuminates the drug-dosed liquid biological sample contained within the illuminated

10 detection chamber.

24. The system of claim 23 wherein the sample positioning mechanism comprises a rotation or carousel mechanism configured to rotate the sample container, so as to sequentially align each of the plurality of detection chambers with the incident beam axis.

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25. The system of claim 23 or claim 24, further comprising a support structure arranged to support the optical apparatus, wherein the support structure comprises an opening configured to receive a portion of the sample container comprising at least one of the plurality of detection chambers, such that when the portion of the sample container is located within the opening, at least one of the plurality of detection chambers is locatable along the incident beam axis between the light source and the light collector.

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26. The system of any of claims 23 to 25, and further comprising a temperature control system configured to maintain the temperature of the liquid biological sample at a temperature between 35° and 37°.

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27. The system of claim 26, wherein the temperature control system comprises a heating arrangement comprises a heating element arranged to generate heat, and a air circulation system configured to evenly distribute the generated heat across the plurality of detection chambers of the sample container.

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28. The system of claim 27, wherein the circulation system comprises at least one recirculation duct and an associated fan arranged to drive airflow across the heating element.

35 29. A method for determining susceptibility of bacteria in a sample to a drug, the method comprising:

containing a drug-dosed liquid biological sample in a detection chamber of a sample container;

illuminating, by a light source, the sample in the detection chamber with light emitted along an incident beam axis that passes through the detection chamber;

5 collecting, by a light collector, light scattered by interaction with bacteria in the sample, the light being scattered in a forward direction in a range of scattering angles between +/-5 and +/-20 degrees relative to the incident beam axis;

concentrating, by the light collector, the collected scattered light onto a first photodetector;

10 determining, by a processor an intensity of scattered light collected by the first photodetector, and a corresponding representative amount or concentration of bacteria particles present in the sample;

repeating, by the processor, the determining step at a series of pre-determined intervals;

15 determining, by the processor, changes in the representative amount or concentration of bacteria in the sample as a function of time; and

determining, by the processor, susceptibility of the bacteria in the sample to the drug used to dose the sample based on the determined changes in the representative amount or concentration of bacteria in the sample as a function of time.

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30. The method of claim 29, wherein the sample container comprises a plurality of detection chambers, at least two of the plurality of detection chambers containing a sample dosed with a different drug, and the method comprises:

25 sequentially locating each of the plurality of detection chambers containing the drug-dosed sample in the light emitted along an incident beam axis;

carrying out each subsequent step of the method in respect of each of the plurality of detection chambers; and

30 determining the relative susceptibility of the bacteria in the samples to the respective drugs used to dose the samples to identify the most effective drug for use in a therapeutic treatment regime.

31. The method of claim 29, wherein the sample container comprises a plurality of detection chambers, at least two of the plurality of detection chambers containing a sample dosed with the same drug at different concentrations of drug, and the method comprises:

35 sequentially locating each of the plurality of detection chambers containing the drug-dosed sample in the light emitted along an incident beam axis;

carrying out each subsequent step of the method in respect of each of the plurality of detection chambers; and

determining the relative susceptibility of the bacteria in the samples to the respective concentrations of the drug used to dose the samples to identify the most effective
5 drug concentration for use in a therapeutic treatment regime.

32. The method of any of claims 29 to 31, comprising:

collecting, by a second photodetector, non-scattered light passing through the or each detection chamber parallel to the incident beam axis; and

10 comparing an intensity of the non-scattered light collected by the second photodetector with an intensity of the scattered light collected by the first photodetector in respect of the same detection chamber.