[0006] CHO, E. coli and other cell cultures are often kept in flasks. In some implementations, flask sizes range between 100 ml and 6 liters. These sizes are often suitable not just for laboratory testing but also for production scale manufacturing. Frequent or constant stirring of the flask contents is often needed. To automate this task, an automatic stirrer may be employed. An automatic stirrer may have a stirring rod, pendulum or other type of agitator located inside the flask and physically, magnetically or otherwise coupled to a driving device located outside the flask. FIGS. 1 and 2 provide examples of prior art automatic stirrers. These are Variomag™ brand magnetic stirrers provided by Thermo Fisher Scientific Inc. of Waltham, Massachusetts USA. FIG. 1 depicts a single system that stirs one flask, and FIG. 2 depicts a multiple system that stirs four flasks simultaneously. In operation, the single system in FIG. 1 involves a stirring device 1, a stirring vessel or flask 2, a power supply 3, a secondary cable 4, a magnetic stirrer base 5 and a rotation speed control button 6. The base 5 of this device is 180 mm wide by 180 mm deep by 60 mm tall. The multiple system shown in FIG. 2 involves stirring devices 1, stirring vessels or flasks 2, a magnetic stirrer base 5', a control cable 7, a power cable 8 and a control unit 9. The base 5' of this device is 330 mm wide by 330 mm deep by 60 mm tall.

[0007] To aid in tightly controlling the environment in stirring vessel(s) 2, the vessel(s) may be placed inside an incubator. Typically, the vessel(s) 2 is/are placed inside the incubator along with a magnetic stirrer base 5, while the power supply 3 and or control unit 9 associated with the stirrer remains outside the incubator. Incubators can be provided with heating and cooling units to control temperature, active humidity controls, interior air circulation systems and HEPA air filtration. An example of a 232 liter capacity incubator suitable for this purpose is a Model No. 3307 Forma™ Steri-Cult™ CO_2 incubator provided by Thermo Fisher Scientific Inc. of Waltham, Massachusetts USA.

[0008] Even with all of the environmental controls outlined above, applicants of the present patent application have found it difficult to tightly control the environmental conditions in cell cultures, in particular, maintaining the temperature of the culture media at 37 °C.

[0009] Accordingly, what is needed and is not provided by the prior art are improved systems and methods for maintaining desired environmental conditions in cell culture media. The innovations described herein solve these unmet needs and provide additional advantages.

SUMMARY OF THE DISCLOSURE

[00010] According to a first aspect of the present disclosure, a thermal separator apparatus for separating a flask and a flask stirrer base may be provided with a stand having a top surface configured to support the flask containing a substance to be stirred by the flask stirrer. The apparatus may also include a plurality of first standoffs located at a bottom surface of the

stand configured to separate the bottom surface of the stand and a top surface of the flask stirrer base. The apparatus may also include a first standoff and a second standoff. When the apparatus is placed on the flask stirrer base,

a first air gap is created between the first and second standoffs, the bottom surface of the stand and the top surface of the flask stirrer base that allows air to flow straight through the first air gap in a first direction.

[00011] In some embodiments of the above apparatus, the first air gap is configured to allow air to flow straight through the first air gap in a second direction, with the second direction being perpendicular to the first direction. The stand and or the first standoffs may include a material having a thermal conductively no higher than about 0.37 W/m·k. In some embodiments, the stand and the plurality of first standoffs are made from polyoxymethylene. In some embodiments, the stand does not have any vertical voids that connect the first air gap to the top surface of the stand.

[00012] In some embodiments, the apparatus may further include a platform having a top surface configured to support the plurality of first standoffs, and a plurality of second standoffs. The second standoffs may be configured to be located between the platform and a flask stirrer base. This arrangement creates a second air gap between the platform and the flask stirrer base that allows air to flow straight through the second air gap in a third direction.

[00013] In some embodiments having a platform and second standoffs, the second air gap is configured to allow air to flow straight through the second air gap in a fourth direction, with the fourth direction being perpendicular to the third direction. The platform and or the second standoffs may include a material having a thermal conductively no higher than about 0.37 W/m·k. In some embodiments, the platform and the plurality of second standoffs are made from polyoxymethylene. In some embodiments, the platform does not have any vertical voids that connect the first air gap to the second air gap.

[00014] In some embodiments having a platform and second standoffs, the first standoffs are laterally offset from the second standoffs. In some embodiments, the third direction is the same as the first direction and the fourth direction is the same as the second direction. The stand and the plurality of first standoffs may form a first stand set, and the apparatus may further include a plurality of substantially identical stand sets located on the top surface of the platform. In some embodiments, the apparatus comprises at least four stand sets. Each of the stands may include a plurality of different diameter recesses, each recess being configured to receive a different size flask.

[00015] In some embodiments, a minimum total horizontal cross-sectional area of the first standoffs does not exceed about 8% of a horizontal cross-sectional area of the stand. In some embodiments, a minimum total horizontal cross-sectional area of the second standoffs does not exceed about 29% of a horizontal cross-sectional area of the platform. In some embodiments, at least about 71% of the first air gap remains unblocked to straight airflow in the first direction. In

some embodiments, at least about 44% of the second air gap remains unblocked to straight airflow in the third direction.

[00016] In some embodiments, the first standoffs are fastened to the platform with non-metallic fasteners. The second standoffs may be integrally formed with the platform. In some embodiments, the apparatus further includes a plurality of tabs projecting downwardly from outside edges of the platform that are configured to keep the apparatus centered on a flask stirrer base. In some embodiments a vertical distance between a bottom surface of any of the recesses and a bottom surface of the second standoffs does not exceed 5 inches. In some embodiments, a vertical distance between a bottom surface of any of the recesses and a bottom surface of the second standoffs does not exceed 1.5 inches.

[00017] According to a second aspect of the present disclosure, a thermal separator apparatus includes a plurality of stands, a platform, a plurality of first standoffs, a plurality of second standoffs and a plurality of tabs. In these embodiments, each stand has a top surface configured to support a flask containing a substance to be stirred by a flask stirrer. The platform has a top surface configured to indirectly support the plurality of stands. The plurality of first standoffs are configured to be located between an associated stand and the top surface of the platform. This arrangement creates a first air gap between each of the stands and the platform that allows air to flow straight through the first air gap in a first direction and in a second direction that is perpendicular to the first direction. The plurality of second standoffs are configured to be located between the platform and a flask stirrer base. This arrangement creates a second air gap between the platform and the flask stirrer base that allows air to flow straight through the second air gap in the first direction and the second direction. The plurality of tabs projects downwardly from outside edges of the platform and the tabs are configured to keep the apparatus centered on the flask stirrer base. The plurality of stands, the platform, the plurality of first standoffs and the plurality of second standoffs each comprise a material having a thermal conductively no higher than about 0.37 W/m·k. The plurality of first standoffs are each laterally offset from each of the second standoffs.

[00018] In some embodiments, a minimum total horizontal cross-sectional area of the first standoffs does not exceed about 8% of a horizontal cross-sectional area of the plurality of stands. In some embodiments, a minimum total horizontal cross-sectional area of the second standoffs does not exceed about 29% of a horizontal cross-sectional area of the platform. In some embodiments, at least about 71% of the first air gaps remain unblocked to straight airflow in the first and the second directions. In some embodiments, at least about 44% of the second air gap remains unblocked to straight airflow in the first and second directions.

[00019] According to a third aspect of the present disclosure, a method of automatically stirring the contents of a flask while closely maintaining the temperature of the contents includes the step

CLAIMS

What is claimed is:

1. A thermal separator apparatus for separating a flask and a flask stirrer base comprising:
a stand having a top surface configured to support the flask containing a substance to be stirred by the flask stirrer base; and
a plurality of first standoffs located at a bottom surface of the stand configured to separate the bottom surface of the stand and a top surface of the flask stirrer base, further comprising a first standoff and a second standoff;
wherein when placed on the flask stirrer base, a first air gap is created between the first and second standoffs, the bottom surface of the stand, and the top surface of the flask stirrer base that allows air to flow straight through the first air gap in a first direction.

2. The apparatus of claim 1, wherein the plurality of first standoffs further comprises a third standoff and a fourth standoff, wherein when placed on the flask stirrer base, a second air gap is created between the second and third standoffs, the bottom surface of the stand, and the top surface of the flask stirrer base that allows air to flow straight through the second air gap in a second direction, the second direction being perpendicular to the first direction.

3. The apparatus of claim 1, wherein the stand comprises a material having a thermal conductivity no higher than 0.37 W/m·k.

4. The apparatus of claim 1, wherein the first standoffs comprise a material having a thermal conductivity no higher than 0.37 W/m·k.

5. The apparatus of claim 1, wherein the stand and the plurality of first standoffs are made from polyoxymethylene.

6. The apparatus of claim 1, wherein the stand does not have any vertical voids that connect the first air gap to the top surface of the stand.

7. The apparatus of claim 1, further comprising:
a platform having a top surface configured to support the plurality of first standoffs; and
a plurality of second standoffs configured to be located between the platform and a flask stirrer base, thereby creating a second air gap between the platform and the flask

stirrer base that allows air to flow straight through the second air gap in a third direction.

8. The apparatus of claim 7, wherein the second air gap is configured to allow air to flow straight through the second air gap in a fourth direction, the fourth direction being perpendicular to the third direction.

9. The apparatus of claim 7, wherein the platform comprises a material having a thermal conductivity no higher than 0.37 W/m·k.

10. The apparatus of claim 7, wherein the second standoffs comprise a material having a thermal conductivity no higher than 0.37 W/m·k.

11. The apparatus of claim 7, wherein the platform and the plurality of second standoffs are made from polyoxymethylene.

12. The apparatus of claim 7, wherein the platform does not have any vertical voids that connect the first air gap to the second air gap.

13. The apparatus of claim 7, wherein the first standoffs are laterally offset from the second standoffs.

14. The apparatus of claim 7, wherein the third direction is the same as the first direction and the fourth direction is the same as the second direction.

15. The apparatus of claim 7, wherein the stand and the plurality of first standoffs form a first stand set, and wherein the apparatus further comprises a plurality of substantially identical stand sets located on the top surface of the platform.

16. The apparatus of claim 15, wherein the apparatus comprises at least four stand sets.

17. The apparatus of claim 16, wherein each of the stands comprises a plurality of different diameter recesses, each recess being configured to receive a different size flask.

18. The apparatus of claim 1, wherein a minimum total horizontal cross-sectional area of the first standoffs does not exceed 8% of a horizontal cross-sectional area of the stand.

19. The apparatus of claim 7, wherein a minimum total horizontal cross-sectional area of the second standoffs does not exceed 29% of a horizontal cross-sectional area of the platform.

20. The apparatus of claim 1, wherein at least 71% of the first air gap remains unblocked to straight airflow in the first direction.

21. The apparatus of claim 7, wherein at least 44% of the second air gap remains unblocked to straight airflow in the third direction.

22. The apparatus of claim 1, wherein the plurality of first standoffs are fastened to the stand with non-metallic fasteners.

23. The apparatus of claim 7, wherein the second standoffs are integrally formed with the platform.

24. The apparatus of claim 7, further comprising a plurality of tabs projecting downwardly from outside edges of the platform and configured to keep the apparatus centered on a flask stirrer base.

25. The apparatus of claim 17, wherein a vertical distance between a bottom surface of any of the recesses and a bottom surface of the second standoffs does not exceed 5 inches.

26. The apparatus of claim 17, wherein a vertical distance between a bottom surface of any of the recesses and a bottom surface of the second standoffs does not exceed 1.5 inches.

27. A thermal separator apparatus comprising:

a plurality of stands, each stand having a top surface configured to support a flask containing a substance to be stirred by a flask stirrer;

a platform having a top surface configured to indirectly support the plurality of stands;

a plurality of first standoffs configured to be located between an associated stand and the top surface of the platform, thereby creating a first air gap between each of the

stands and the platform that allows air to flow straight through the first air gap in a first direction and in a second direction that is perpendicular to the first direction;

a plurality of second standoffs configured to be located between the platform and a flask stirrer base, thereby creating a second air gap between the platform and the flask stirrer base that allows air to flow straight through the second air gap in the first direction and the second direction; and

a plurality of tabs projecting downwardly from outside edges of the platform and configured to keep the apparatus centered on the flask stirrer base,

wherein the plurality of stands, the platform, the plurality of first standoffs and the plurality of second standoffs each comprise a material having a thermal conductively no higher than 0.37 W/m·k,

wherein the plurality of first standoffs are each laterally offset from each of the second standoffs.

28. The apparatus of claim 27, wherein a minimum total horizontal cross-sectional area of the first standoffs does not exceed 8% of a horizontal cross-sectional area of the plurality of stands.

29. The apparatus of claim 27, wherein a minimum total horizontal cross-sectional area of the second standoffs does not exceed 29% of a horizontal cross-sectional area of the platform.

30. The apparatus of claim 27, wherein at least 71% of the first air gaps remain unblocked to straight airflow in the first and the second directions.

31. The apparatus of claim 27, wherein at least 44% of the second air gap remains unblocked to straight airflow in the first and second directions.

32. A method of automatically stirring the contents of a flask while closely maintaining the temperature of the contents, the method comprising:

providing an automatic stirring device having a base;

providing a thermal separator apparatus according to claim 27 and placing it over the base of the stirring device;

placing a flask on at least one of the plurality of stands of the thermal separator apparatus, the at least one flask have contents to be stirred and a stirrer magnetically coupled to the stirring device base;

locating the automatic stirring device, the thermal separator apparatus and the at least one flask in a temperature-controlled incubator; and

allowing air to circulate through the first and the second air gaps of the thermal separator apparatus.