Microcosm for Bacteria and Plant Roots

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Function:

The microcosm apparatus should consist of large seed pore for settlement of plant seed, a trapezoid chamber for root growth, an outlet pore for extracting material and assisting airflow, one or two inlet pores for media and bacteria insertion or settlement of two different bacteria. The material for the apparatus should be crystal clear for microscopy, oxygen permeable for bacteria growth and root growth, biologically inert for plants and bacteria and resistive to possible deformation caused autoclave. The apparatus should be able to be disassembled easily for studying the interaction between bacteria and plant roots under microscopy.

Problem Statement:

Researchers developed an apparatus which can allow observation and study of the interaction between bacteria and plant root and possible structures formed by bacteria under the condition of culturing media and sand. However, the current prototype lacks the ability to test the effects of competing types of bacteria on the plant root, the ability to be reused and is not friendly to users. In order to improve the functionality of the apparatus and the efficiency of the research procedure, a microcosm apparatus with inlet and outlet pores, separated ports for different bacteria and detachable structure needs to be developed by either modifying the prototype or designing a new one.

Client requirements:

- Apparatus size can fit into the microscope platform
- Upper layer material permeable to oxygen
- Material transparent to observe the bacteria under the microscope
- Inner chamber for root growth and interaction between roots and bacteria
- Include an inlet for culturing liquid, bacteria, and sand/plant seed
- Include an outlet for drawing out the liquid and preventing spills while loading
- Include pores for different bacteria

- Detachable structure to simplify the extraction process
- Better be reusable to lower the experiment cost

Design requirements:

1. Physical and Operational Characteristics

a. Performance requirements:

- Culturing media and sand can be loaded into the chamber without causing any blockage
- The substances can be extracted easily from the chamber after observations
- Apparatus can be autoclaved and reused for at least 10 times without deformation and color change.

b. Safety:

- Bacteria should not leak from the chamber
- The material used should not contain any possible toxin to human

c. Accuracy and Reliability:

- The apparatus must provide a clear view of the inner chamber
- The sight should still be clear after multiple reuses
- The size and dimensions should be constant after multiple autoclaves and reuses
- The dimensions of the inner structure of the device should be precise in micrometers.

d. Life in Service:

- The chamber should maintain the structure within multiple reuses
- The design protocol must be easily repeatable for future fabrication of the device.
- The device should remain reliable during normal use during the experiment

e. Operating Environment:

- The top part and the bottom part should be sealed together to avoid leakage of media and experiment subjects.

f. Ergonomics:

- The upper part must not be too thick to reduce the oxygen permeability and cause significant refraction of light.
- The device must be able to be assembled to the platform of the microscope easily and stably.
- The opening-and-closing mechanism must not cause inconvenience to the users.

g. Size:

- The device must be small enough to fit on the microscope platform

h. Weight:

- The device does not have a weight restriction

i. Materials:

- The top part, used for inspection and later microscopy, will be made out of PDMS, since it is one of the most used materials for molding of microfluidics devices due to its high transparency for microscopy, easily bonding ability with a simple plasma treatment, leak-proof ability, gas permeability, inexpensiveness, and easiness for molding[1]
- The lower compartment, used as a chamber for holding roots, bacteria, sand, and media will be made out of polystyrene, since it is widely used for medical applications, like tissue culture trays,[3] and can be easily injection molded[4]

j. Aesthetics, Appearance, and Finish:

- The apparatus should be manufactured smoothly without blurring on layers

2. Production Characteristics

a. Quantity: 1 (prototype).

b. The total cost of the device should be less than $250.

3. Miscellaneous

a. Standards and Specifications:

- No international or national standards need to be met while the device is in the prototype phase of the design process.

b. Customer:

- The customer expects a device that can be seen through into the chamber that is holding liquid medium/sand and plant roots to observe the interactions of bacteria and plant roots by using a microscope. The customer would like it to be detachable so the customer can easily access the inside of the chamber without cutting into it and having to make a new prototype every test.

c. Patient-related concerns:

- The device must be sterilized between uses. The top and bottom parts of the device must also be leak proof to prevent bacteria or anything spilling out and coming into contact with humans.

d. Competition:

Indoor microcosmic ecological simulation experimental device and ecological simulation experimental method (CN107167564A)
A microcosm for raising plants under biotic and abiotic conditioning (EP3236741A1)
Microcosm inspection equipment (JP3891518B2)

A microfluidic co-cultivation platform to investigate microbial interactions at defined microenvironments[2]

Sources:

- [1]Elveflow. (2019). *PDMS: A review - Elveflow*. [online] Available at: https://www.elveflow.com/microfluidic-tutorials/microfluidic-reviews-and-tutorials/the-poly-di-methyl-siloxane-pdms-and-microfluidics/ [Accessed 20 Sep. 2019].
- [2]Burmeister, A. (2019). *A microfluidic co-cultivation platform to investigate microbial interactions at defined microenvironments. - PubMed - NCBI*. [online] Ncbi.nlm.nih.gov. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30488920 [Accessed 20 Sep. 2019].
- [3]ChemicalSafetyFacts.org, "What is Polystyrene?: Uses, Benefits, and Safety Facts," *ChemicalSafetyFacts.org*, 17-Jun-2019. [Online]. Available: https://www.chemicalsafetyfacts.org/polystyrene/. [Accessed: 20-Sep-2019].
- [4]T. Rogers, "Everything You Need To Know About Polystyrene (PS)," *Everything You Need To Know About Polystyrene (PS)*. [Online]. Available: https://www.creativemechanisms.com/blog/polystyrene-ps-plastic. [Accessed: 20-Sep-2019].