Fluidization of fungal pellets using miniaturized 3D-printed fluidized bed

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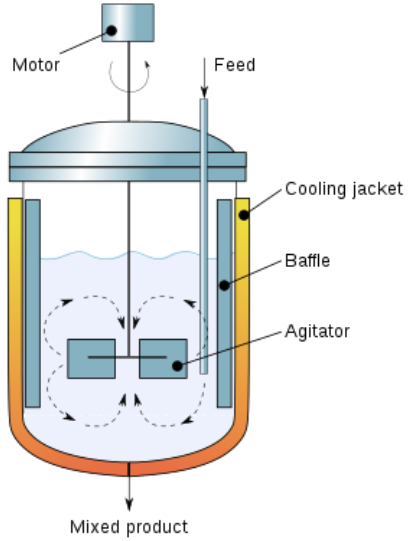
1 Project background

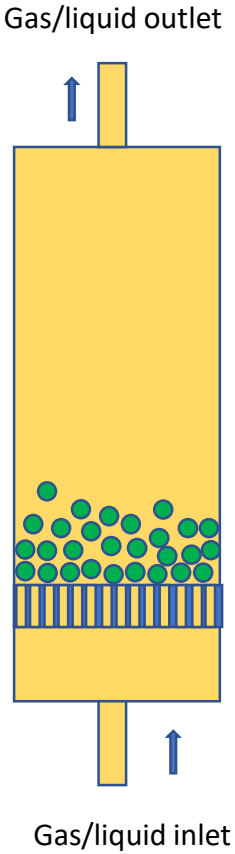
- Poor mixing
- Not scaleable
- Short-term culture

Culture flask

- High capital cost
- Shear stress
- Cell damage/death



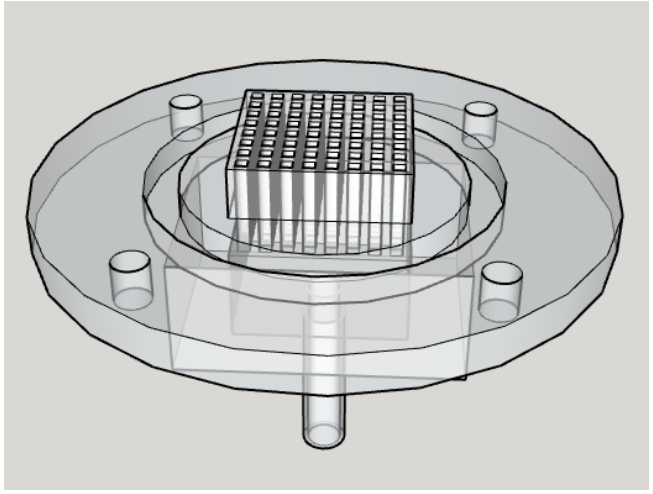
Stirred-tank reactor



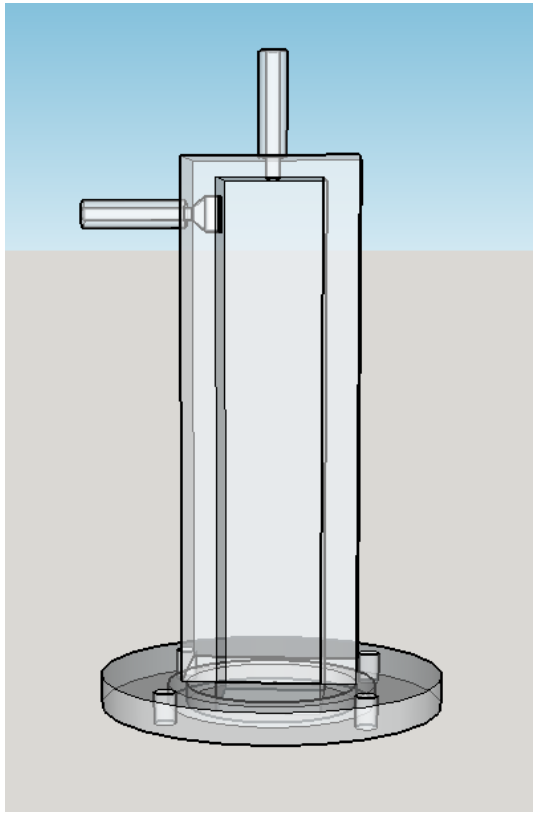
- Good mixing
- Low shear stress
- Simplified construction

Fluidized bed reactor

- Fluidized bed design and fabrication



Lower Part



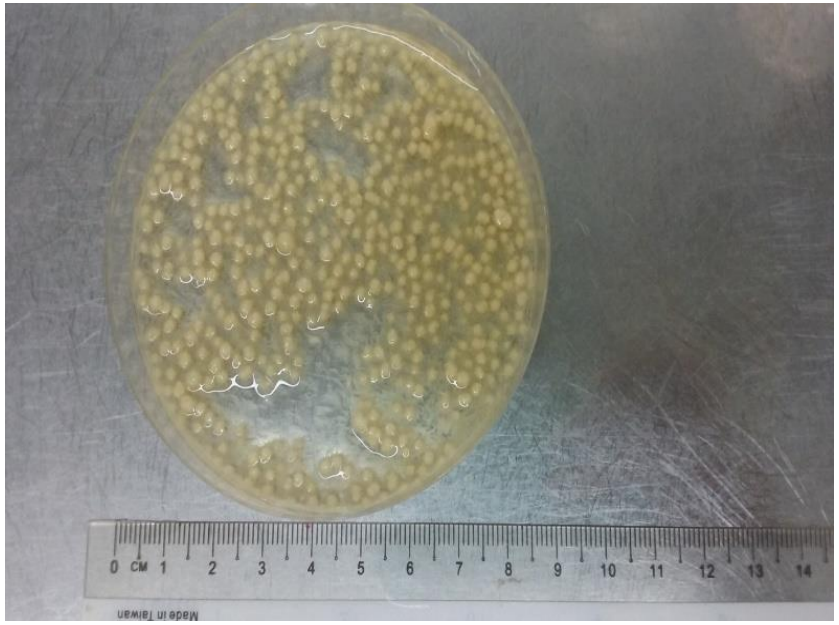
Upper Part

Assembled fluidized bed

- Designed by: Google SketchUp
- Printed by: Form2 SLA printer
- Cross-section: 15×15 mm; Bed height: 15 mm
- Planar distributor (5 mm in height): contains 1mm square holes

- Fungal pellets

Fungi in nature



Fungal pellets in petri dish

Single Pellet in microscope

Fungal cells: *Nidula niveo-tomentosa* (Bird's nest fungi)
Size: ~2mm
Density: $1.1 g/cm^3$
Pellet properties unique to fungi are an important consideration

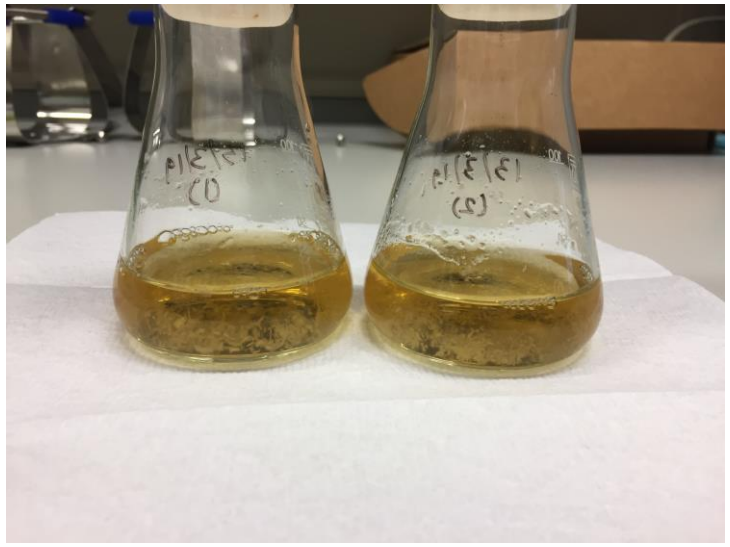
- Culture medium

Density: 1.02 g/cm^3
Viscosity: 1.1 mPa.S

Components of cultivation medium

Components in Media	Concentration (g/L)
glucose monohydrate	50
peptone from soy	6
potassium dihydrogen phosphate	2.5
magnesium sulfate	0.5
yeast extract	1.5
calcium chloride dihydrate	.0735
Ultrapure H2O	fill up to 1 L

- Fungal pellets fluidization



Flask culture

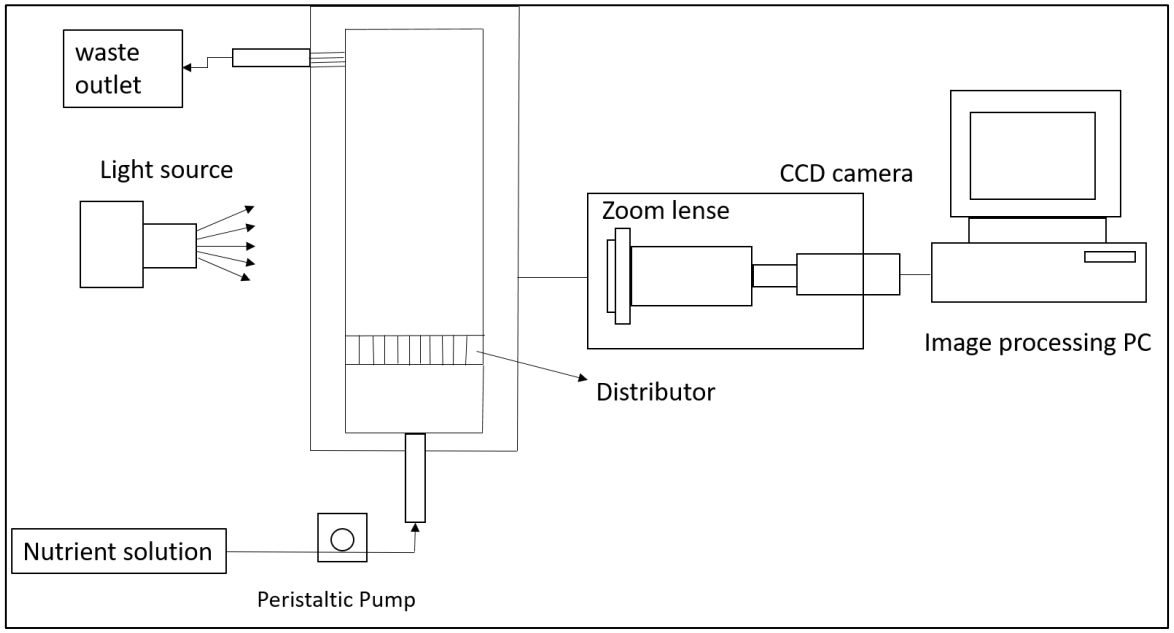
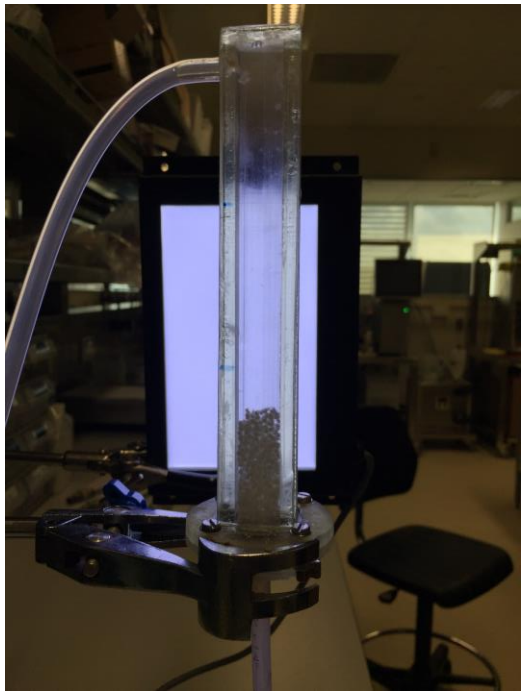
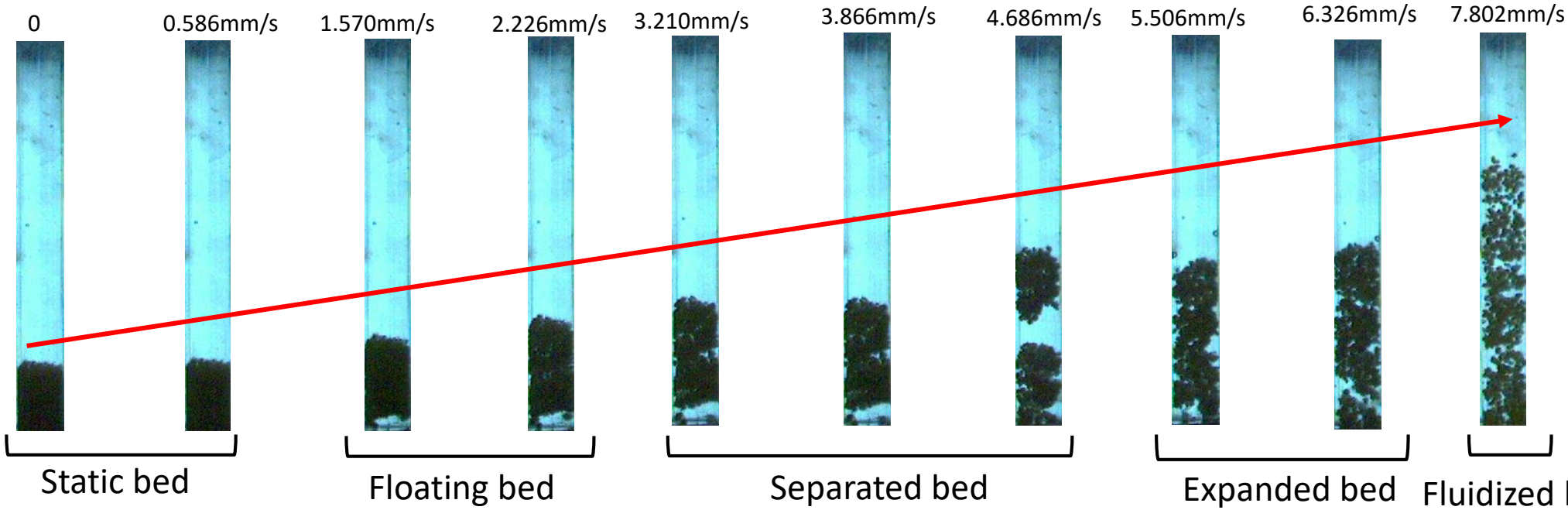


Diagram of experimental setup



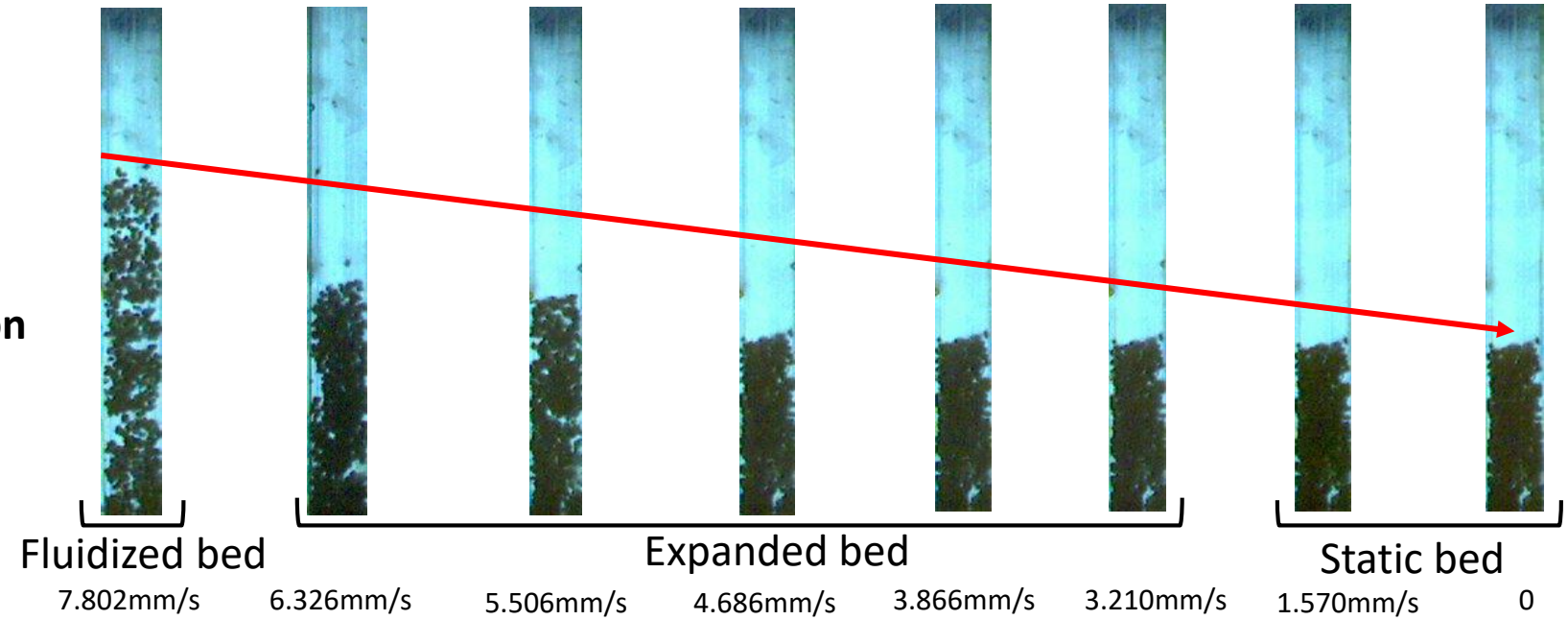
Fluidization process

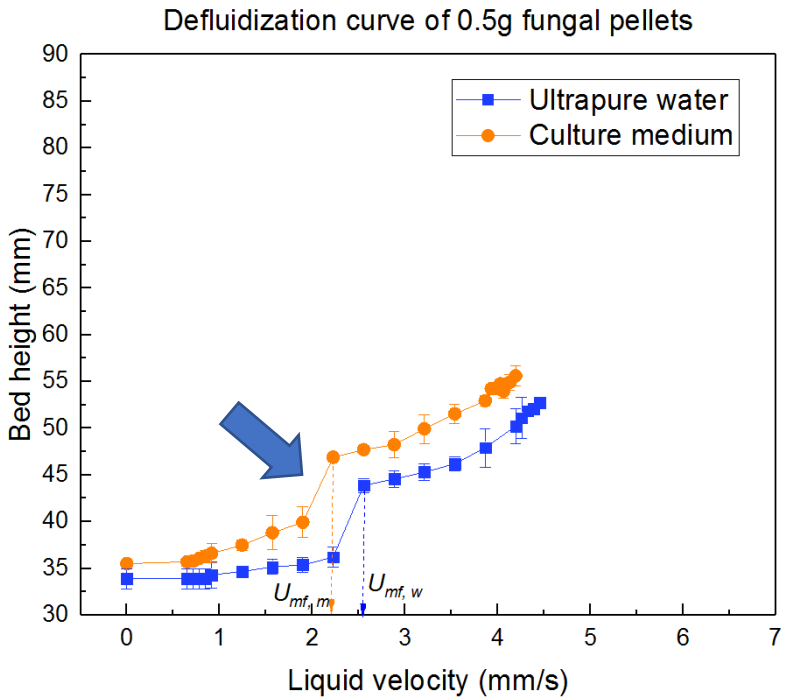
Fluidization

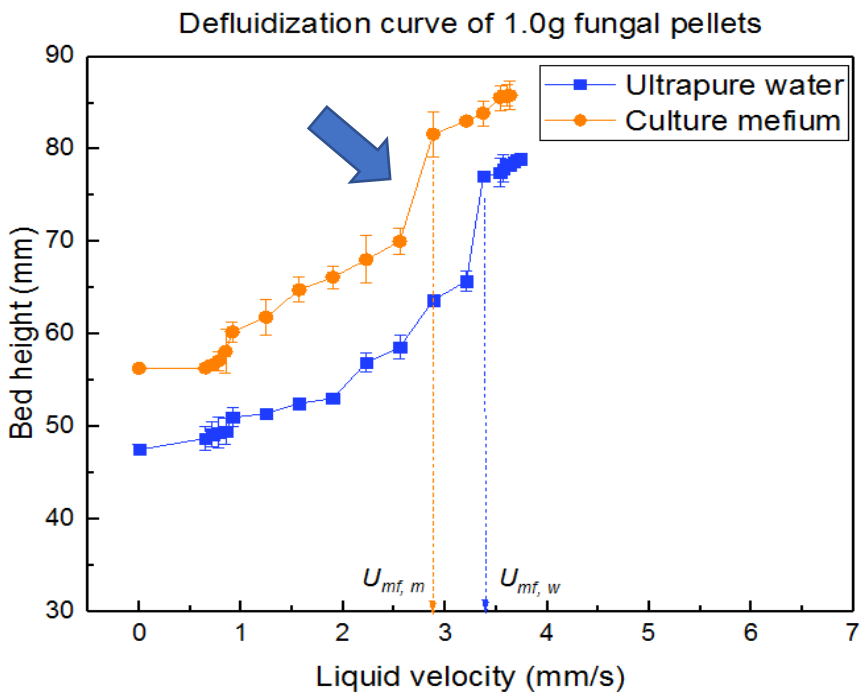


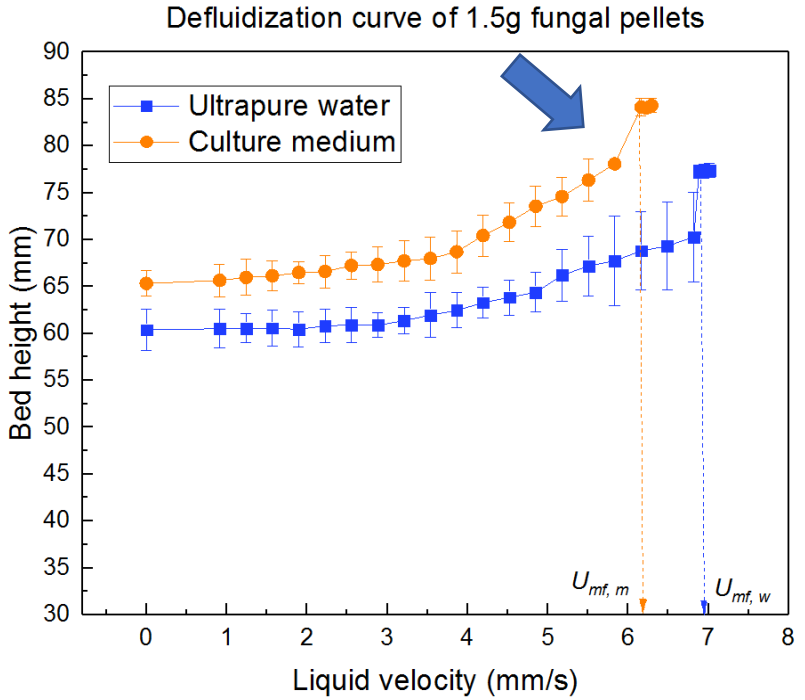
Pellets fluidization

Defluidization









- The bed height jump occurs when agglomerated pellets become dispersed and fully fluidized, when liquid velocity reaches U_{mf};
- The U_{mf} is increasing with mass of fungal cells as the voidage of initial packed bed is increasing with overall mass.

- **Ergun equation**

$$U_{mf} = \frac{{d_P}^2(\rho_P - \rho_L)g}{150\mu_L}\left(\frac{\varepsilon^3 {\emptyset_P}^2}{1-\varepsilon}\right)$$

Pellets mass (g)	0.5		1.0		1.5	
Initial bed voidage, ε_0	0.38		0.43		0.51	
Liquid type	Ultrapure water	Culture medium	Ultrapure water	Culture medium	Ultrapure water	Culture medium
Experimental Minimum fluidization velocity (mm/s) $U_{mf,e}$	2.226	1.898	3.210	2.554	6.818	6.162
Theoretical minimum fluidization velocity (mm/s) $U_{mf,th}$	1.869	1.669	2.698	2.409	5.71	5.105

5 Summary

- There are some transitional regime (separated bed, expanded bed) before actual fluidization regime start usually not present in liquid fluidization.

- The agglomerated fungal pellets are separated into dispersed pellets and homogenously fluidized by the liquid flow when liquid velocity reaches the U_{mf}.

- The homogenous fluidization and suspension of pellets exhibit the feasibility of fungal fermentation using fluidized bed bioreactor.

- The experimental value of $U_{mf,e}$ is larger than $U_{mf,th}$ calculated from Ergun equation, mostly due to increase of initial voidage (wall effects) but possible due to surface forces (cohesive forces between pellets).

Future work:

- Fungal pellets fluidization characterization
- Fermentation in gas-liquid-solid fluidized bed (aeration)

Questions?

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