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Determining the effects on yeast cell size and count when varying orifice tube size using the Coulter Principle

Ashley Lovering, Jack G. Saad, & Rick Shimkus, Micromeritics Instrument Corporation

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ABSTRACT

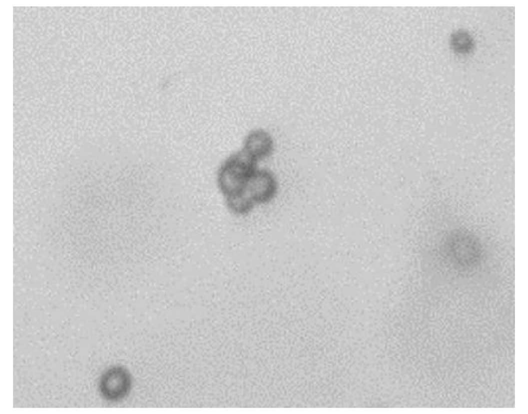
Yeast cell health and reproduction rates are commonly characterized using electric sensing zone (ESZ) technology, which is based on the Coulter Principle. This technique involves two cells of electrolyte solution separated by an insulating barrier through which there is a cylindrical orifice. The reservoirs have opposite electrical charge causing an electrical current to flow through the orifice channel while a pumping mechanism also causes the electrolyte to flow through the same orifice channel. As electrolyte is flowing, yeast cells present in the electrolyte will pass through the orifice displacing electrolyte and creating an electrical resistance in the electrical current. The size of the resistance is proportional to the volume of the yeast cell and the number of times a resistance appears correlates to yeast cell count. Choosing the appropriate orifice size for the yeast cells being characterized is vital to collecting accurate data. Each orifice size has a specific size detection range. Using varying extreme size differences in orifices that have overlapping size ranges to characterize common yeast cells used in beer brewing, size and count data is compared and contrasted.

MATERIALS

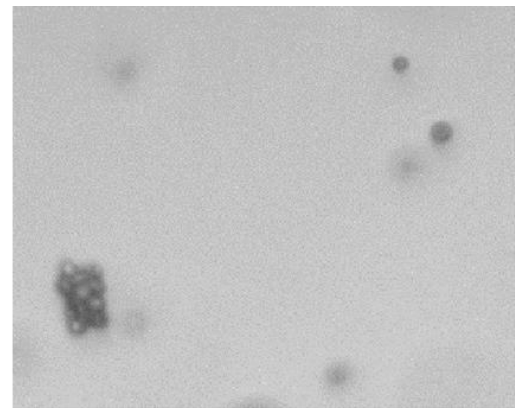
A sample of dry lager yeast and a sample of ale yeast are hydrated and added to separate worts to ferment.

After fermentation, approximately 5 drops of each suspension is added to 50mL of 2% NaCl and dispersed with glass stirrer. The two preparations are analyzed using a 48 and 95 micron orifice tube on an electric sensing zone (ESZ) instrument. 50,000 particles were counted using each tube.

Dry Lager Yeast



Ale Yeast



METHODS

Electrical Sensing Zone Analysis

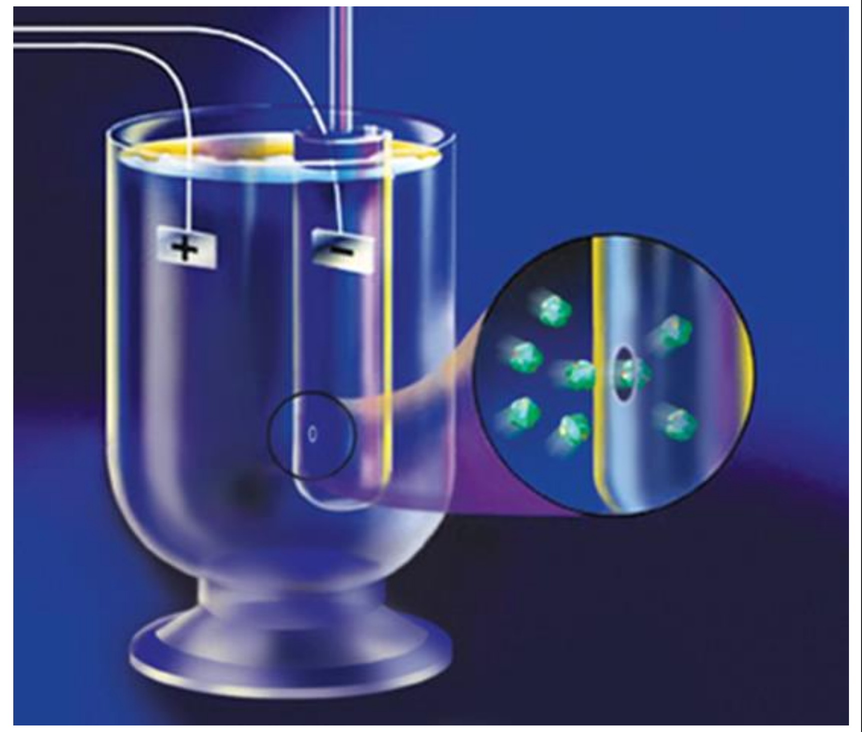
Measures changes in resistance and reports volume and equivalent spherical diameter using the Coulter Principle.

Two cells of electrolyte are separated by an insulating barrier through which there is a cylindrical orifice. The reservoirs have opposite electrical charge. Therefore, current flows through the orifice channel along with the electrolyte. When a particle passes through the orifice, the displaced electrolyte causes a resistance to the electrical current. The magnitude of the resistance is proportional to the volume of the particle. From the volume of the particle, the equivalent spherical diameter can be calculated.

The end-to-end resistance (R_i)of a linear conductor of constant cross section is:

$$R_i = \frac{\rho L}{A}$$

ρ = the resistivity of the electrolyte (Ω·m),
L = the length of the orifice, and
A = the cross-sectional area of the orifice, which is changed when a particle enters the orifice.



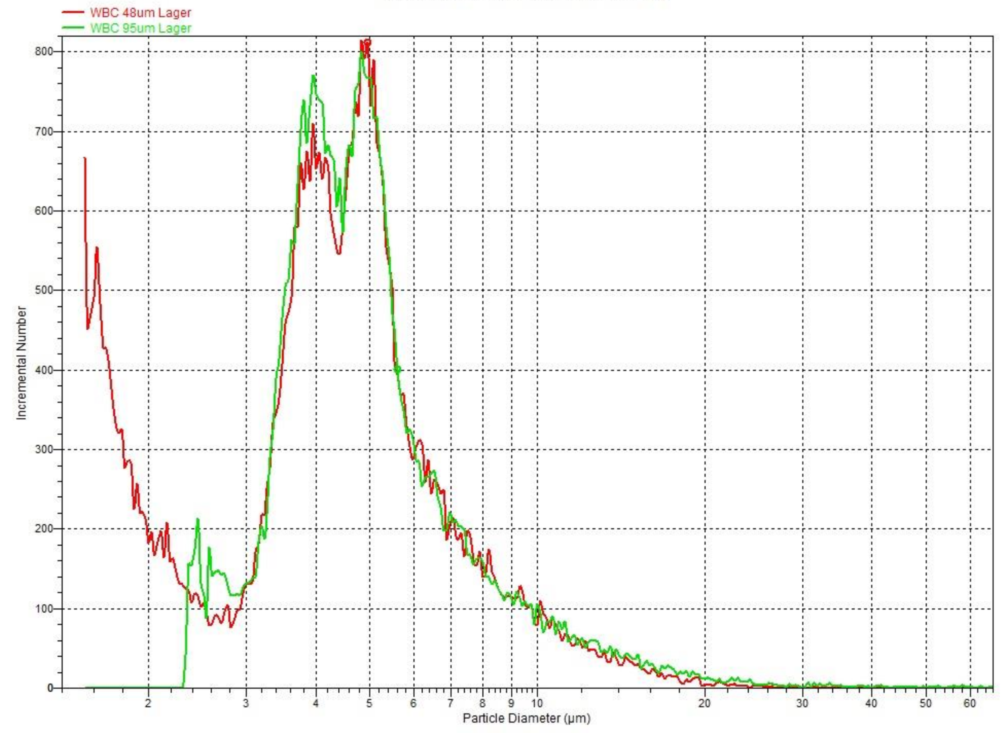
Analytical Assumptions and Constraints:

- The particles are electrically nonconductive
- The particle size range is appropriate for the orifice diameter
- The concentration of the particles is such that the probability of more than one particle being in the orifice at the same time is negligible.
- The length of the longest elongated particle is less than the length of the orifice.

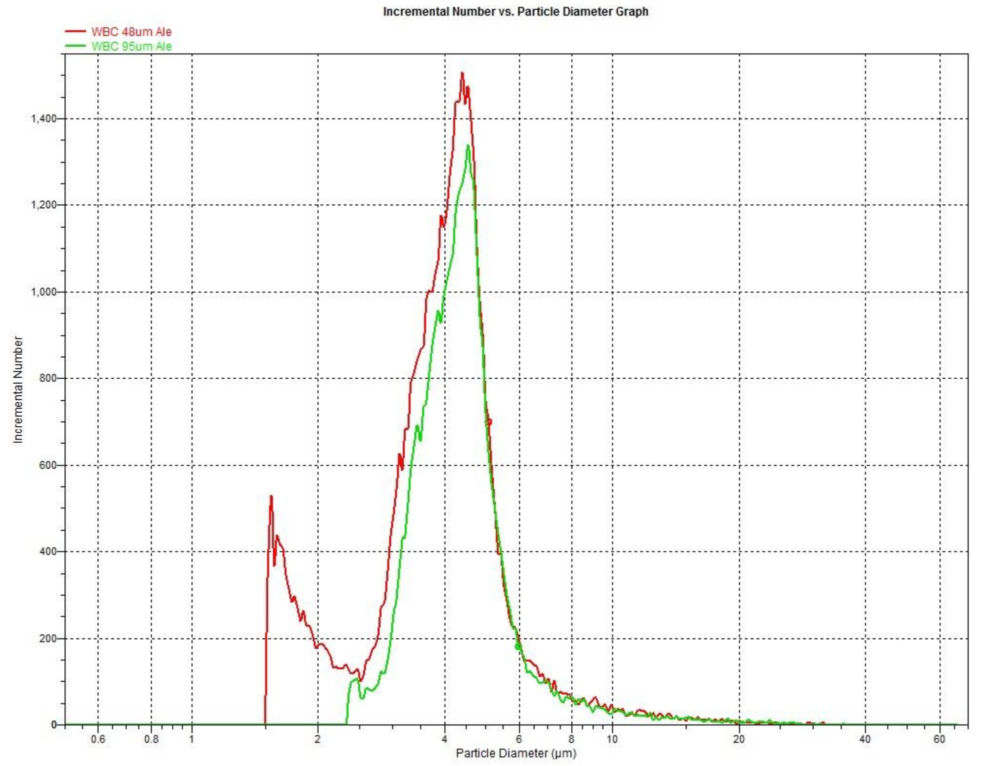
For non-spherical particles, d is *"the diameter of a sphere of the same material that produces the same change in electrical resistance as that of the measured particle."* ***Equivalent Spherical Diameter by ESZ, or Coulter diameter***

RESULTS

Dry Lager Yeast
Size Overlay



Ale Yeast
Size Overlay



CONCLUSIONS

The measureable size range for particles is typically 2-70% of the diameter of the orifice tube selected. The 48 micron tube has a measureable size range of 1-33 microns and the 95 micron tube has a measureable size range of 2-66 microns.

The results from the electric sensing zone analysis of the dry lager yeast cells show similar size distributions on two different orifice tubes. Based on the graphical data, the mode of the primary peak of the dry lager yeast cell is about 4.8 microns, regardless of which tube is used.

The results for the ale yeast cells show a similar agreement between the two different size orifice tubes. Based on the graphical data, the mode of the primary peak of the ale yeast cell is about 4.26 microns.

The overlays demonstrate that changing the cross-sectional area of the orifice and holding the radius constant does not affect the data calculation. Using a larger orifice tube helps eliminate the frequency of blockages while the use of a smaller orifice tube helps eliminate noise. Both orifice tubes are suitable for the analyzing the yeast cells.

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