The comparison of MICP between two different bacteria strains in low temperature condition

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Materials and Methods

Temperature as a key factor contributes to the amounts of calcium carbonate precipitation induced by microbes. At low temperature, low urease activity will result in a lack of calcium precipitation. In this paper, Sporosarcina pasteurii (S. pasteurii ATCC 11859), and Bacillus megaterium (B. megaterium ATCC 14581) were chosen for comparative studies, both of which were cultured on Luria Bertani medium, comprising of yeast extract 15.0 g/L, polypeptone 10.0 g/L, NaCl 10.0 g/L, and distilled water. To compareively study effects of temperature on absorbance (Fredrickson et al., 2001), urease activity (Ferris et al., 2004) and productive rates for calcium carbonate ($\text{productive rates} = \frac{\text{actual amount of calcium carbonate}}{\text{theoretic total amount of calcium carbonate}}$), temperature was maintained at four levels: 15、20、25 and 30℃. Initial pH of nutrient solution was 7.0, and triplicate samples of each condition were prepared. Two kinds of bacteria were inoculated with close OD_{600} (1.138 and 1.122) to reduce errors. The concentration of calcium acetate and urea in mixed solution for precipitation reaction were both 0.5 mol/L. Absorbance, urease activity and productive rates were monitored in the 48-hour cultivation.

Results

The effect of temperature on growth pattern of two bacteria

It can be observed in **Fig. 1** that the speed of growth of S. pasteurii and eventual stable value both rose with increase of temperature. But the OD_{600} at low temperature of 15℃ accounted for less than one fourth of it with other temperature in the 12th hour. As for absorbance curves of B. megaterium, they were basically similar between 20℃ and 30℃, especially at the initial 10 h. The bacterial concentration at 15℃accounted for about 50 % of other curves in the 12th hour. Absorbance curves at 15℃ of them were specifically compared to choose relatively suitable strain for low-temperature applications. The speed and the absorbance of reproduction with B. megaterium both outstripped S. pasteurii from the beginning to the end. The maximum OD_{600} of B. megaterium almost equalled to 0.8, compared with 0.6 for S. pasteurii.

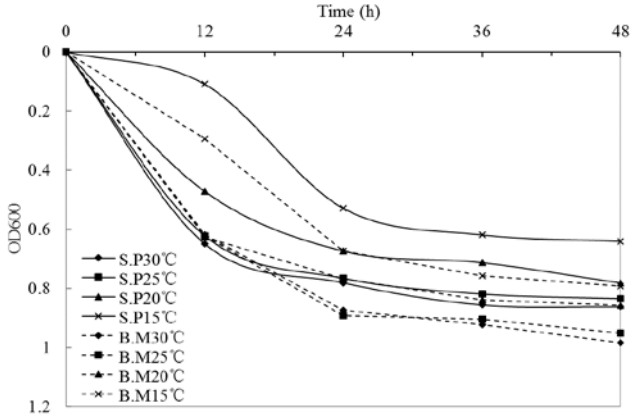

Fig. 1: The effect of temperature on the growth of two bacteria

The effect of temperature on urease activity of two bacteria

As shown in **Fig. 2**, the differences with B. megaterium were by no means big, specially between 25℃ and 30℃, meaning that urease activity curves were relatively adjacent. Entirely different phenomenon could be seen with S. Pasteurii. The improvement of urease activity was evidenced with temperature increasing. At high temperature of 25℃ or 30℃, ultimate urease activities of B. megaterium were lower than its opponent. Urease

activity curves with 15℃ of them were specifically compared as well. The rising speed and ultimate values of urease activity of B. megaterium were both larger than those of S. pasteurii. Consequently, in low temperature condition, urease activity of B. megaterium was extremely higher than S. pasteurii.

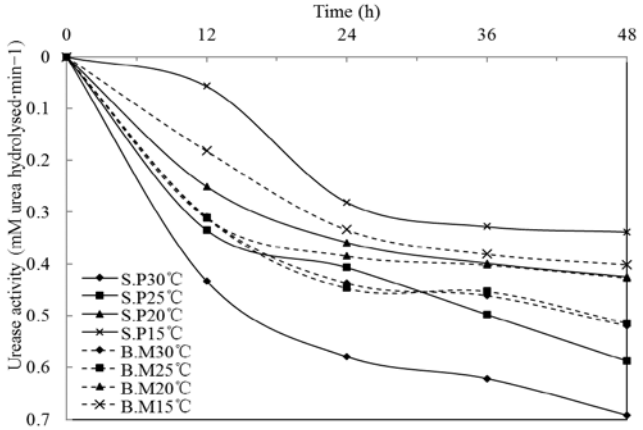

Fig. 2: The effect of temperature on urease activity of two bacteria

The effect of temperature on productive rates for calcium carbonate of two bacteria

Fig. 3 shows that with higher temperature, productive rates for calcium precipitation of two strains was bigger. Compared with S. pasteurii, the difference of productive rates with B. megaterium was smaller. At temperature of 30℃, B. megaterium could produce less calcium precipitation than S. pasteurii in the early phase, whereas both of them maximized at about 27%. As for low temperature of 15℃, much more calcium precipitation was obtained with B. megaterium and productive rates experienced a bigger increasing trend during 4-day reaction, eventually reaching 16%, approximately twice as high as that of S. pasteurii.

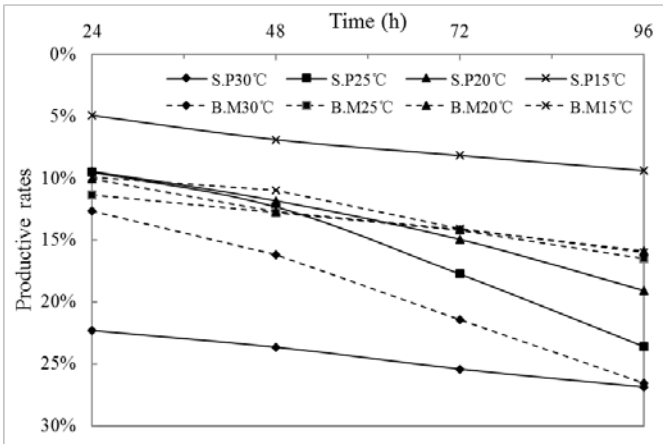

Fig. 3: The effect of temperature on productive rates for calcium carbonate of two bacteria

Conclusions

Different temperatures were commanded to analyze some characters of S. pasteurii and B. megaterium.The conclusions are that the speed of reproduction of B. megaterium is distinctly higher than its opponent, S. Pasteurii, at low temperature. In different temperature conditions, the urease activities of B. megaterium are similar. At high temperature, B. megaterium has a lower urease activity, while surpasses S. Pasteurii at low temperature. The same results also exist in productive rates for calcium carbonate. Therefore, at low temperature, MICP method with B. megaterium can be applied for some engineering fields, due to environmental benefits of MICP (Eric et al., 2010).

References

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