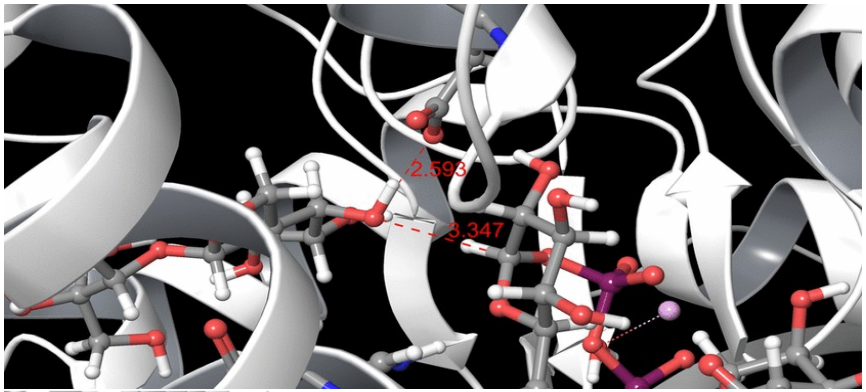
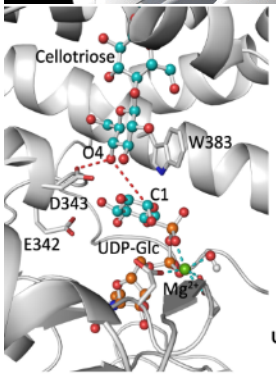
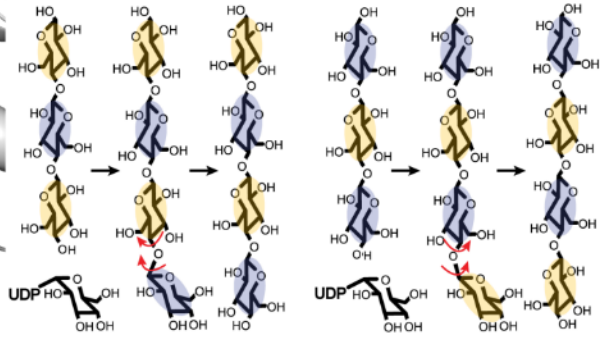
QM/MM Investigation of the Molecular Mechanism of Cellulose Polymerization in Bacterial CESA

Scientific Achievement

Our QM/MM analyses provide the first theoretical model of the mechanism by which BcsA, a member of processive glycosyltransferases, elongates a cellulose polymer one glucosyl moiety at a time.







Yang, H.; Zimmer, J.; Yingling, Y. G.; Kubicki, J. D., How Cellulose Elongates - a QM/MM Study of the Molecular Mechanism of Cellulose Polymerization in Bacterial CESA. *J. Phys. Chem. B* 2015, DOI: 10.1021/acs.jpcb.5b01433.

Significance and Impact

This study provides detailed insights into how cellulose is formed which provides us with better ability to understand the effects of enzyme mutations and ability to engineering cellulose formation.

Research Details

- Identified a S_N-2-type transition structure corresponding to the nucleophilic attack of the non-reducing end O_4 on the anomeric C_1, the breaking of the glycosidic bond C_1-O_1, and the transfer of proton from the non-reducing end O_4 to the general base D343;
- The activation barrier found for this S_N-2-type transition state is 68 kJ/mol. The rate constant of polymerization is estimated to be ~8.0 s^{-1} via transition state theory;
- The newly added glucosyl residue rotates into the plane of the cellulose polymer, where it is stabilized by intramolecular hydrogen bonds with the penultimate glucose unit.

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