Kink generation by the association of 2D clusters

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Abstract:

The density of kinks along the growth steps of a faceted crystal scales the step velocity and hence the rate of growth of the crystal. The classical mechanism of kink generation, as a result of the thermal fluctuations of the step edge, was put forth by J. W. Gibbs; Burton, Cabrera and Frank posited that density of kinks generated be this mechanism will not increase in a supersaturated solution. In the 1970, it was proposed that on steps of low kink density, additional kinks may be generated by the one-dimensional nucleation of new crystal rows.

We demonstrate for the crystallization of Zn-insulin a novel mechanism of kink generation, whereby 2D clusters of several insulin molecules pre-formed on the terraces between steps associate to the steps. This mechanism results in several-fold higher kink density, faster rate of crystallization, and a high sensitivity of the kinetics to small increases of the solute concentration.

Rhombohedral crystals of Zn-insulin hexamers form in the islets of Langerhans in the pancreases of many mammals. The suggested function of crystal formation is to protect the insulin from proteases and increase the degree of conversion of soluble proinsulin. To accomplish this, crystal growth should be fast and adaptable to rate fluctuations in the conversion reaction.

If the found mechanism operates during insulin crystallization in vivo, it could be a part of the biological regulation of insulin production and function. For other crystallizing materials in biological and non-biological systems, this mechanism provides an understanding of the often seen non-linear acceleration of the kinetics.

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