

## PHYSICOCHEMICAL PROPERTIES OF THE SOLID PHASES OF WATER: ICES

Water is probably the most important molecule presents in nature. It forms the matrix of life<sup>1</sup>, it is the most common solvent for chemical processes, it plays a major role in the determination of the climate on earth, and it also appears on planets, moons and comets<sup>2</sup>. Water is interesting not only from a practical point of view, but also from a fundamental point of view. In the solid phase it exhibits one of the most complex phase diagrams. Currently, sixteen different ice phases are known for water. Ice formation is relevant to microbiology<sup>3</sup>, food industry<sup>4</sup>, materials science<sup>5</sup>, geology<sup>6</sup>, and physics<sup>7</sup>. Due to its importance and its complexity, understanding the physicochemical properties of water and ices from a molecular point of view it becomes crucial<sup>8,9</sup>.

<sup>1</sup> P. Ball, *Life's Matrix. A Biography of Water*, University of California Press, Berkeley (2001).

<sup>2</sup> J. P. Poirier, *Nature*, 299, 683 (1982).

<sup>3</sup> S. S. Hirano and C. D. Upper, *Microbiol. Mol. Biol. Rev.* 64, 624 (2000).

<sup>4</sup> J. K. Li and T. C. Lee, *Trends Food Sci. Technol.* 6, 259 (1995).

<sup>5</sup> A. Michaelides and K. Morgenstern, *Nat. Mater.* 6, 597 (2007).

<sup>6</sup> A. G. Gerrard, *Rocks and Landforms*, Springer, Netherlands (1988).

<sup>7</sup> H. R. Pruppacher, *J. Atmos. Sci.* 52, 1924 (1995).

<sup>8</sup> D. Eisenberg and W. Kauzmann, *The Structure and Properties of Water*, Oxford University Press, London, (1969).

<sup>9</sup> V. F. Petrenko and R. W. Whitworth, *Physics of Ice*, Oxford University Press, Oxford (1999).

- 1) Importance of water molecule. Hydrogen bond
- 2) Anomalous properties of water
- 3) Phase diagram of water
- 4) Ice Ih
- 5) Liquid layer of ice
- 6) Competition between ices Ih and Ic
- 7) Ices at high pressures
- 8) Ices at negative pressures
- 9) Other ice structures: clathrate hydrates
- 10) Presence of ice in the space
- 11) Water potential models for studies at molecular level