Thermozymes: An area of potential research

Research on extremophiles, i.e. organisms able to survive and thrive in extreme environmental conditions, as promising sources of highly stable enzymes (extremozymes) has been active in the present decade[1]. The enzymes from organisms adapted to extreme environments called extremozymes have been grouped into various categories such as enzymes that function at high temperatures (thermozymes), high salt levels (halozymes), under alkaline conditions (alkalozymes) and other extreme conditions such as pressure, acidity, etc.

The thermophilic enzymes (thermozymes) have generated wide interest due to their inherent stability and wide applicability. With the discovery of *Thermus aquaticus* by T. D. Brock and his colleagues in 1969, and subsequently, the *Taq* DNA polymerase have brought about a revolution in the field of molecular biology and biotechnology, and focused on the potential of thermozymes.

Thermophilic enzymes are barely active in the temperature range of 20–30°C, but become fully active at temperatures higher than the optimal growth temperatures of other organisms. These enzymes develop unique structural and functional properties of high thermostability and optimal activity at temperatures above 70°C; some of the enzymes discovered are found to be active at temperatures of 110°C and above. Thermophilic enzymes are more rigid proteins than the mesophilic enzymes, but little work has been done in this area.

Natural environments include hot springs, deep-sea hot sediments and deep geothermally heated oil-containing stratifications. Hydrothermal vents are considered to be potential sources of thermophiles and consequently of the thermozymes. Isolation of the organisms is not easy. Microbiologists estimate that <10% of all organisms existing in a given environment is actually cultivable.

Thermozymes that are stable and active at high temperatures offer major biotechnological advantages over their counterparts.

(i) They can be purified easily by heat treatment when expressed in the mesophilic hosts.

(ii) Due to their thermostability, they have high resistance to chemical denaturants, such as organic solvents required for the synthesis of fine chemicals in cases where substrates are poorly water-soluble.

(iii) Enzyme reactions performed at high temperatures allow higher substrate concentrations, lower viscosity, reduction in the risk of contamination and high reaction rates.

In recent years thermophilic proteases, lipases and polymer degrading enzymes such as cellulases, gelatinases and amylases have found their way into biotechnological and industrial applications[2]. Thermozymes are natural models of stable proteins and are remarkable tools for innovative biotechnological processes. These enzymes can serve as model systems to be used by the biologists, physicists and chemists to study and understand enzyme evolution, protein thermostability mechanisms, and minimum and maximum temperature limits of enzyme function.

Research on thermozymes and their exploration coupled with better understanding of their structural properties may help in the development of proteins with desired catalytic and thermal properties. This will also lead to the development of better and newer protein engineering strategies and can be exploited for designing a wide range of biotechnological and industrial molecules in the near future.

1. Herbert, R., *Trends Biotechnol.*, 1992, **7**, 349–353.
2. Satyanarayana, T., Raghukumar, C. and Sivaji, S., *Curr. Sci.*, 2005, **89**, 78–90.

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Palynology in India: What is the future?

Palynology is a fascinating science with a multidimensional approach covering almost all branches of botanical sciences. It is segregated into many sub-branches such as: 'aeropalynology' dealing with pollen contained in the air and pollen allergy; 'palaeopalynology' dealing with fossil pollen which is also useful in interpretation of ancient flora (pollen spectrum is helpful in oil exploration); 'melissopalynology' encompassing honey pollen analysis and honey bee flora, including pollination ecology; 'nutritional palynology' or pollen chemistry, a subject which elaborates the chemical and nutritional contents of pollen, both for insects and human beings, and 'pollen histo-chemistry' for study of pollen–stigma interaction and incompatibility systems in plants. Besides these, pollen germination, culture and hybridization are other areas of pollen-based research. It may further be emphasized that the new advanced researches encompassing biodiversity, molecular biology, gene-mapping and DNA fingerprinting are all areas depending on the basic unit of reproduction in plants – the pollen. Can we possibly ignore such an integral reproductive entity? The significance of pollen and therefore the study of pollen grains (palynology) is vital for all plant-based researches.

Palynological studies in India were initiated by Wodehouse in 1935 and reached greater heights with the efforts of subsequent pioneer workers like G. Erdtman and P. K. K. Nair. With the advent of electron microscopy, the subject received a new impetus. Several other palynologists emerged in our country during 1960–90, but soon they switched over to other areas due to lack of infrastructure. Slowly the subject dwindled to a few pockets of the National Research Laboratories by the end of 20th century.