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**Advancements of two dimensional correlation spectroscopy in protein researches**

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**ABSTRACT**

The developments of two-dimensional correlation spectroscopy (2DCOS) applications in protein studies are discussed, especially for the past two decades. The powerful utilities of 2DCOS combined with various analytical techniques in protein studies are summarized. The emphasis is on the vibration spectroscopic techniques including IR, NIR, Raman and optical activity (ROA), as well as vibration circular dichroism (VCD) and fluorescence spectroscopy. In addition, some new developments, such as hetero-spectral 2DCOS, moving-window correlation, and model based correlation, are also reviewed for their utility in the investigation of the secondary structure, denaturation, folding and unfolding changes of protein. Finally, the new possibility and challenges of 2DCOS in protein research are highlighted as well.

Keywords:

Two-dimensional correlation spectroscopy; Protein; Vibrational spectroscopy; Vibration circular dichroism; Fluorescence spectroscopy

**1. Introduction**

It is well known and accepted that the importance of protein flexibility and dynamics in molecular recognition and conformational stability. The aggregation of proteins has important technical implications in disease treatment and biotechnology. Nevertheless, whether the process of protein folding/unfolding is fully cooperative or it contains sequential elements has long been a fundamental issue to be solved in protein science, until the appearance of generalized two-dimensional correlation spectroscopy (2DCOS) in 1990s [1-2].

The basic concept of the generalized 2DCOS is described briefly in this review, since it has been well introduced in the literature [1-10]. In 2DCOS, a set of spectra $A(v_j, t_i)$ is obtained firstly as a function of the spectral variable $v_j$ with $j$ = 1, 2, ... $n$ and some perturbation variable $t_i$ with $i$ =