

Zeitschrift: Archives des sciences et compte rendu des séances de la Société
Herausgeber: Société de Physique et d'Histoire Naturelle de Genève
Band: 42 (1989)
Heft: 1: Archives des Sciences

Artikel: Polarity : from dipoles to biopolarizations. III. Addenda
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Kapitel: II: Molecular dipoles and chirals
DOI: <https://doi.org/10.5169/seals-740082>

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II. MOLECULAR DIPOLES AND CHIRALS

A. ELECTRIC DIPOLE MOMENTS

Many neutral molecules are examples of charge systems with non-ideal electric dipole moments expressed in Debye units (see II.A in I), since in most types of molecules the centres of gravity of the positive and negative charge distribution do not coincide (Böttcher *et al.*, 1973).

Tables of experimental dipole moments can be consulted in McClellan (1963) and Exner (1975). Electron scattering by polar molecules has been studied by Itikawa (1978) and mechanical considerations given to elimination reactions over polar catalysts by Noller and Kladnig (1976). Polar dielectrics and their applications (Burfoot and Taylor, 1979), polar covalence (Sanderson, 1983), and preparative polar organic chemistry (Brandsma and Verkruisse, 1987) have been reviewed.

The formation of a supramolecular crystal is the result of a repulsion between neighbouring domains, as it is the case for charged colloidal particles (Prost and Rondelez, 1991). As all the dipoles point in the same direction, each domain can be considered as a macrodipole that repels its neighbours (Andelman *et al.*, 1987; McConnell and Moy, 1988).

Atoms and molecules adsorbed on room-temperature surfaces can be manipulated by voltage pulse applied between the sample and probe tip of a scanning tunneling microscope. The adsorbed atoms (Cs, etc.) are induced to diffuse into the region beneath the tip "by the action of the electric field gradient at the surface on the adsorbate dipole moment" (Whitman *et al.*, 1991).

Surface dipole-dipole (Attard *et al.*, 1988) in their interplay with other forces (van der Waals, electrostatic, etc.) depend on interactions between membranes in a stack (Richetti *et al.*, 1990). The dynamic process of electronic energy transfer (DET) between donor and acceptor molecules in condensed phases is an important tool for probing the microstructure of spatially confined molecular systems. This DET mechanism, first introduced in 1948 by Förster, is a dipole-dipole-dominated reaction in which an electronic excitation initially localized on a donor, is resonantly transferred to an acceptor located at a given distance (Drake *et al.*, 1991).

In his search for electric dipole moments of the neutron, atoms and molecules, Hunter (1991) mentioned "the first crack in the edifice of perfect symmetry" resulting from Lee and Yang suggestion made in 1956 that the symmetry of parity "might be violated in the weak interactions", a suggestion soon confirmed in 1957 by the observation of an asymmetry in the β emission of polarized ^{60}Co by Wu *et al.*

B. MINERAL Dipoles

1) *Dipolar water*

Water is singular as a liquid because of its ability to form three-dimensional molecular networks, mutually hydrogen bonded (Wiggins, 1990). Its molecules are in a state of high energy if they fail to make the maximal number of hydrogen bonds possible either with one another or with solutes or surfaces (Finney, 1979 and 1982 (II); Wiggins, 1990). These new facts thus disprove Ling's (1962) association-induction hypothesis according to which water could be polarized in multilayers on protein surfaces. Wiggins' scheme of hydration of charged groups corresponds to a two-dimensional arrangement of water molecules round two negatively charged sites on a surface.

Biological processes implicate transient changes in active-site water structure that offer a simple mechanism for enzymes which perform chemical work. Synthesis of ATP, reaction of the Ca-ATPase are striking examples of the power of this newly described biological force which depends for its generation upon charged dipolar molecules and several other factors (Wiggins, 1990). It thus becomes more and more evident that the intracellular status of water is intimately connected with bioenergetics.

Freezing of water to ice is a most common example of symmetry-breaking phase transition. When the translational and rotational symmetry of the water is "broken", the system takes on the discrete symmetry of the ice crystal (Chuang *et al.*, 1991).

D. CHIRAL MOLECULES

Chemical methods of asymmetric synthesis have been reviewed by Brown and Davies (1989). The molecular recognition process involves a combination of attractive forces (electrostatic or van der Waals) and steric repulsion. Differential biological effects of the two chiral forms of drugs such as thalidomide have also been again emphasized.

Chiral symmetry breaking has recently been demonstrated by autocatalysis and competition between L- and D- crystals of sodium chlorate (Kondepudi *et al.*, 1990). This revealing experiment, realized under polarized light, might help to understand how most of the molecules of life, including DNA, RNA, and proteins, came to exist preferentially in a right-handed or left-handed form. Asymmetric synthesis involves catalysts such as Cu and Fe for their reaction (Brown and Davies, 1989). Such controlled synthesis involving a novel titanium complex might even lead to the creation of three-dimensional structures (Brown, 1991).

The major non-histone component of the metaphase scaffold is topoisomerase II. In compact chromosomes the scaffolding is helically folded with sister chromatids having predominantly opposite helical handedness (Boy de la Tour and Laemmli,

1988). Considering the secondary structure of nucleic acids, Holliday (1990) shows that RNA molecules could exist in left- or right-handed forms. "The sequences of bases in the stem and the side arms are the same, but the latter are inserted at different positions while retaining the same sequence polarity". Only one or another of these asymmetric molecules might be transcribed from DNA and asymmetry could be lost or reversed by mutations. Such considerations are of relevance for the problem of RNA structures encoded by maternal DNA in the asymmetric coiling of snail shells (see VIII.3.e).

Studies of extraterrestrial amino acids have suggested that the characteristic "handedness" of biochemistry on Earth may ultimately have been determined by an asymmetry already existing in such compounds such as of L- and D-enantiomers of alanine which rotate the plane of polarization of light in opposite directions. The excess of the L-enantiomer was found to be indigenous (Murchison meteorite) rather than terrestrial contamination, suggesting that optically active materials "were present in the early Solar system before life began" (Engel *et al.*, 1990).

A symposium has been devoted to "chirality and biological activity" (Holmstedt *et al.*, 1989).