J. Appl. Cryst. (1974). 7, 180

Small-Angle X-ray Scattering Studies of Human-Serum Lipoproteins

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Human-serum low and high-density lipoproteins were studied in solution by small-angle X-ray scattering techniques in the presence of variable amounts of NaBr (used for the purpose of raising the electron density of the solvent). The observation of a few diffraction fringes separated by low minima indicates that both classes of lipoproteins are fairly homogeneous and that the particles display a quasi-spherical symmetry. Assuming that the solvent does not penetrate the particles the spherical component of the electron density distribution can be determined on an absolute scale. Furthermore making the hypothesis that the particles can be described by two electron-density levels corresponding to the paraffin and polar regions, the fraction of the volume occupied by each component can be determined at any radius. The two particles were found to be structurally different: LDL contains a spherical lipid bilayer whose average radius is 65 Å. The outer surface appears to be covered by a loose two-dimensional network of 60 protein subunits. Instead HDL seems to be formed by a lipid core of about 30 Å radius partially covered by protein subunits with an important fraction of the polar groups of the lipids exposed to the solvent.

J. Appl. Cryst. (1974). 7, 180

Small-Angle X-ray and Neutron Diffraction from Membrane Structures

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The envelopes of lipid-containing viruses and the nerve myelin sheath are differentiated membrane structures whose molecular architecture and interactions are being analyzed by coordinated small-angle diffraction methods. The lipid hydrocarbon forms the central water-excluding layer of these membranes. The scattering amplitude density of hydrocarbon is small for X-rays and slightly negative for neutrons. The contrast for X-ray scattering from the bilayer can be varied by adding electron-dense solutes to the aqueous medium; even greater variation in contrast for neutrons can be obtained by replacing the weakly negative scattering H_2O with strongly positive scattering D_2O. X-ray patterns from several different uniform-size enveloped virus particles show sharp fringes corresponding to the particle diameters which are in the range 600–1000 Å. Changes in the diffraction pattern in media of different electron density establish the density of solvent impermeable regions. The density profiles demonstrate the bilayer arrangement of membrane lipids. The lamellar lattice of the myelin sheath is formed by a spiral wrapping of a pair of membranes with a repeat period which can vary from about 120 Å to over 200 Å depending on environmental conditions. Comparative X-ray and neutron diffraction measurements have established the arrangement of lipid, protein and water in the native membrane array. The kinetics of structural rearrangements have been followed from changes in diffraction patterns. The intensity changes produced by replacing H_2O with D_2O measure the rate of exchange and the amount of water in the structure.