

# 8th International Symposium on Hybridized Materials with Super-Functions

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# Proceedings

Edited By:

CA: SÍNTESIS Y PROCESAMIENTO DE CERÁMICOS  
Y COMPUESTOS

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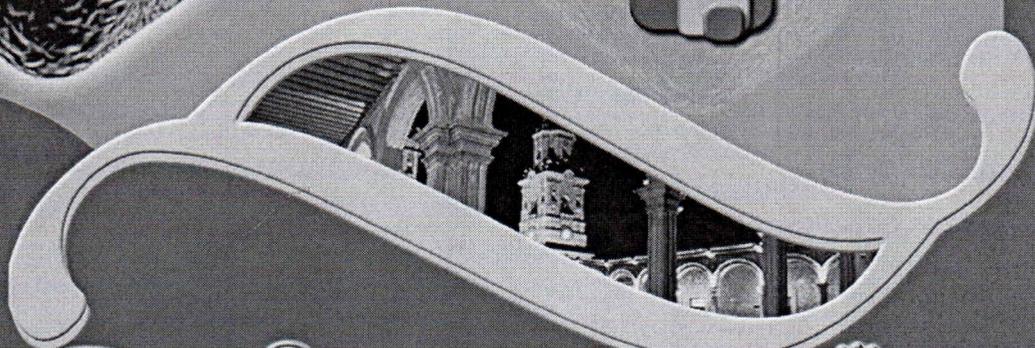
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## VISUALIZATION AND CHARACTERIZATION OF CHOLESTEROL ADLAYERS ON Au(111) BY STM

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Studies of cholesterol as important component of cell membrane are of great importance in modern medicine, molecular biology and biochemistry [1]. Chemically, cholesterol has a cyclopentanepentahydrophenanthrene core, a hydroxyl group in carbon number 3, a lateral chain of 8 carbon atoms, a double bond in C-5 position and five methyl groups in C-18, C-19, C-21, C-26 y C-27 positions respectively. Due to its structure cholesterol poses amphipathic character. Most of the molecule is hydrophobic (water insoluble), except the hydrophilic part: OH-terminal [2].

Crystallographic data revealed cholesterol crystal phase with triclinic symmetry, with one of dimension: 1.71 nm [3, 4]. This data is very close to molecular size calculated in our study by PC SPARTAN plus software: 1.7 nm large, 0.4 nm width and 0.4 nm height (Fig. 1).

Since no soluble in aqueous media, cholesterol is transported inside the human body by lipoproteins which are a combination of macromolecules like proteins, triglycerides and phospholipids. The most common forms of lipoproteins are LDL and HDL. The excess of accumulation of lipoproteins inside arteries it is known as arteriosclerosis disease [5].

The scanning tunneling microscopy (STM) is a modern surface science technique that makes possible to visualize surfaces of different materials, including materials with a biological origin, at molecular and atomic scale. STM imaging is based on direct, real space and real surface observations, and works in variety of media including the body fluids. Beside topography and atomic structure determination, it also offers characterization of the surface electronic properties.

In our study, cholesterol adlayers adsorbed at Au(111) from different solvents and from solutions of different concentrations, were visualized by STM at molecular level. The obtained images clearly show that film structure and film properties as well as mode of interaction between the adsorbed molecules and the substrate, depend of the concentration and solvent properties.

### Methodology

The cholesterol samples (Aldrich, 99+%) for STM analysis were prepared from  $2 \times 10^{-4}$  M solution in methanol (Aldrich, 99.93%). Molecular adlayer were formed directly on Au(111) substrate (Berlinear Glas Co), especially prepared as described before [6]. The surface morphology of the molecular films were visualized by STM microscopy (STM Nanoscope IIIa, Digital Instruments, Santa Barbara, CA), in ex-situ conditions at the room temperature.

### Results and discussion

The high resolution STM images of cholesterol molecular film prepared from  $2 \times 10^{-4}$  M methanol solution, at Au (111) surface are presented at figure 2. As obvious from the obtained images, the gold surface is completely covered by a compact cholesterol film. Indeed, about 25% of the surface is cholesterol free (dark patches in the surface film). Absence of cholesterol is seen at large terraces and not so at the step edges of the sample. In the adsorbed layer molecules seems to be closely packed, without some especial order. Appearance of the cholesterol free zones in the molecular film could be related to way of their intermolecular interactions, as a predominant force in the film formation. No relation to the Au(111) symmetry, was observed. Detail analysis shows that molecular film is 0.29 nm high, which is in good agreement with calculated value from PC SPARTAN plus software simulation. It

undoubtedly demonstrates that imaged films consist from monolayer of adsorbed cholesterol on Au(111) [7].

Taking into account all these findings, a suitable model of the molecular adlayer was developed. Figure 3, shows a most likely structure of the cholesterol monolayer formed at the Au(111) substrate, with hydrophilic part attached to the gold surface. Independently of the solvent (methanol, water, etc.) and independently of the aggregated state in the solution (micelle, vesicle and lamellas) we found that first step is a formation of the monolayer film, with specific and characteristic defects. These findings could be of special importance in design of the molecular devices.

### Conclusion

The cholesterol molecular films prepared from different solutions on the Au (111) substrate were characterized by STM at atomic and molecular levels. High resolution STM images revealed monolayer nature of the prepared films, consisted from the closely packed cholesterol molecules, oriented by hydrophilic parts toward the gold substrate. Independently to the used solvent and solution concentration, films always appeared by same type of surface defects. A simple model was developed to explain structure and mode of interactions in the cholesterol monolayer film.

### Acknowledgments

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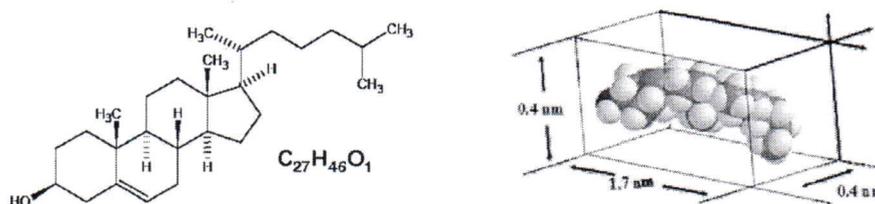


Figure 1: Structure and dimensions of free cholesterol molecule (74 atoms) PC SPARTAN plus

Figure 2:  
STM image of cholesterol  
monolayer on Au(111) substrate,  
prepared from  $2 \times 10^{-4}$ M methanol  
solution,

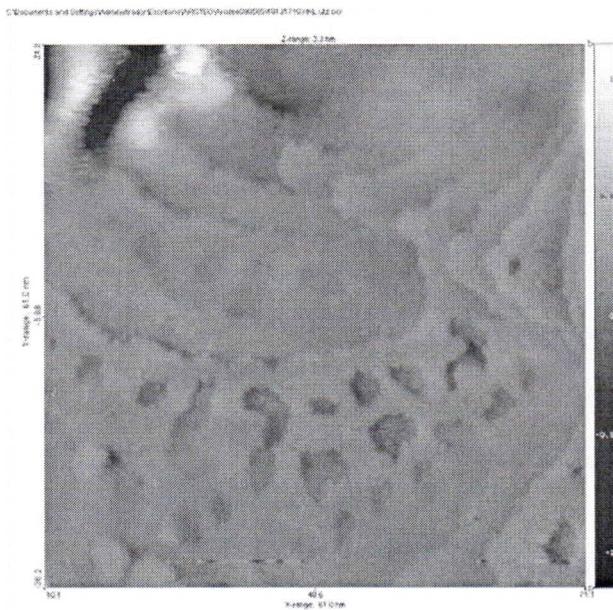


Figure 3:  
Molecular adlayer prepared from  
 $2 \times 10^{-4}$ M methanol solution on Au(111)  
substrate, with individual cholesterol  
molecules identified in monolayer film,  
by STM.

