

CIAIPc Molecular Growth Study at Low and High coverages

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Phthalocyanines (Pc) molecules (Fig. 1a) are π -conjugated systems that host metal atoms at their center. A non-planar sub-family exists, functionalized by a pair of atoms creating a dipole perpendicular to the Pc backbone. These molecules are studied for the development of sensors [1] and light-emitting diodes [2]. Our molecule of interest, chloroaluminium phthalocyanine (CIAIPc), has been reported to arrange into both Cl-up and a Cl-down orientation, where the dipole points either towards the surface or the vacuum (Fig. 1b). Previous studies on the growth of CIAIPc monolayers (MLs) report different molecular orientations within the ML on Au(111) [3], which motivates our study of the impact of various growth conditions.

Here, both STM and nc-AFM experiments were performed at room temperature (RT) and low temperature (LT). Under low molecular coverage on Au(111), LT imaging revealed that isolated CIAIPc molecules appear in both Cl-up and Cl-down configurations (Fig. 1c,d). In STM images, the Pc backbones of both orientations appear as four-lobed structures, but the difference lies at their center: a dark pit is observed for Cl-down, whereas a bright protrusion is seen for Cl-up (Fig. 1c). Similarly, in nc-AFM images (Fig. 1d), the two orientations can be distinguished by different features at the middle of the molecule. Moreover, the Cl-down molecules appear to be tilted on the Au(111) surface compared to the Cl-up (Fig. 1e,f).

At higher coverage, under both RT and LT conditions, CIAIPc molecular domains form a bilayer before the completing the first monolayer on Au(111) surface. This is observed regardless the system used or the operation temperature conditions, the bilayer structure consists of Cl-down molecules in the bottom layer and Cl-up molecules in the top layer, respectively.

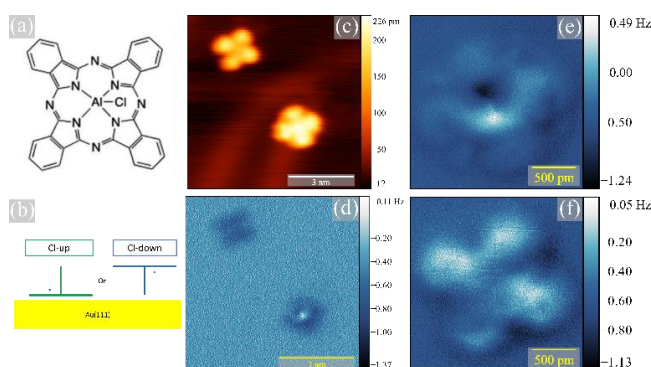


Figure 1. (a) Schematics of CIAIPc molecular drawing and (b) the two possible orientations on the substrate. (c) LT STM image of both Cl-up and Cl-down orientation ($V_b = -1V$, $I_t = 10pA$) and (d) its corresponding nc-AFM image ($f = 990kHz$, $A = 100pm$). (e) and (f) Zoomed-in nc-AFM images of Cl-up and Cl-down molecules, respectively.

REFERENCES

1. Chani M. et al., Physica E. 45, 77-81 (2021)
2. Deng Z. et al., Solid-State Electronics. 85, 22-35 (2013)
3. Huang Y. L. et al. Small, 8, 9, 1423-1428 (2012)