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# Archimedean Tiling Phases from ABC Starpolymers: The Road to Polymeric Quasicrystals

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ABC 星型ブロック共重合体のミクロ相分離によって，テキスタイルのような２次元タイル３色塗り分け紋様ができることが明らかになってきた．最近，分子周りの環境の複雑なアルキメデスタイリング ($3^2$.4.3.4) 構造が実験的に発見されたが，これは複雑な合金相として知られる Frank-Kasper 相（$\sigma$ 相）と類似な構造で，12 回対称準結晶の近似結晶になっている．われわれの ABC 星型高分子の格子モンテカルロシミュレーションは 12 回対称高分子準結晶の可能性を示唆している。

## 1 Introduction

It is has been numerically and experimentally shown that ABC star block terpolymers produce three-colored two-dimensional tilings like textile designs.[1] See Fig.1. It should be noted that these tilings are well described by Archimedean tilings studied in Harmonices Mundi II (1619) by Kepler. Recently, we have found a more complex Archimedean tiling ($3^2$.4.3.4), consisting of triangles and squares, closely related to the $\sigma$ phase of the Frank-Kasper metallic alloy family.[2] This highly complex Archimedean tiling structure covers a wide variety of materials, demonstrating that the complexity is universal over different hierarchy: The edge length of polygons are ~0.5nm for alloys (NiV, NiCr), ~2nm for chalcogenide (TaTe), ~10nm for organic dendrons, and ~80nm for ABC star terpolymers. The ($3^2$.4.3.4) phase is akin to the dodecagonal quasicrystal, and in every other system with different length scale, it is known that both ($3^2$.4.3.4) and quasicrystalline phases always appear with a slight composition change.

## 2 Numerical study of a polymeric dodecagonal quasicrystal

We report the formation of a dodecagonal quasicrystal (DDQC) and Archimedean tilings in a quasi-two-dimensional lattice Monte Carlo simulation of a star-shaped three component polymeric alloy.[3] In simulations, with increasing C component, a series of phases ($4.8^2$) → ($3^2$.4.3.4) → DDQC → (4.6.12) is observed. The structure function is almost twelvefold for A9B7C14, and the simulation box with periodic boundary conditions (128*128*10) can be regarded as the Stampfli inflation of the ($3^2$.4.3.4) tiling, an approximant of the DDQC (Fig.1 (g) and (h)).

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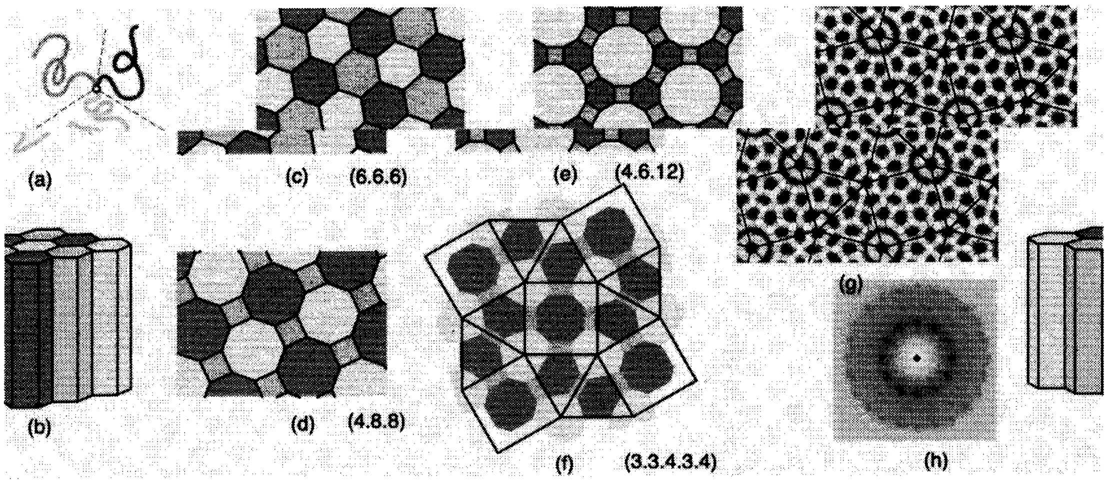


Figure 1: Archimedean tiling and dodecagonal quasicrystalline phases from ABC star polymers. Archimedean tiling is the tiling that only one type of vertices in each tiling is allowed. (a) ABC star terpolymer; (b) and (c) ($6^3$), (d) ($4.8^2$), (e) (4.6.12), (f) ($3^2$.4.3.4) phases. (g) Simulation result for A9B7C14 star block copolymers with two-periodic visualization: A (transparent), B (light) and C (dark). (h) Structure function of the C component for (g).

Thus the result is at best we could achieve in a periodic box. The corresponding edge length of deflated squares and triangles is thought to be about 300 nm. Furthermore, the consecutive tiling rearrangement of the deflated square-triangle tiling is dramatically observed at an elevated temperature, demonstrating the existence of dynamic phasons that are the additional degrees of freedom in quasicrystals. We have measured twelvefold order parameter, specific heat, and phason fluctuations. A natural mean field theory describing the Archimedean tiling phases indicates that the DDQC is a high temperature phase. We suggests that the ABC starblock terpolymer may offer the road to polymeric quasicrystals.

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