Formula unlocks secrets of cauliflower's geometry

October 23 2012

The laws that govern how intricate surface patterns, such as those found in the cauliflower, develop over time have been described, for the first time, by a group of European researchers.

In a study published today, 24 October, in the Institute of Physics and German Physical Society's New Journal of Physics, researchers have provided a mathematical formula to describe the processes that dictate how cauliflower-like patterns – a type of fractal pattern – form and develop.

The term fractal defines a pattern that, when you take a small part of it, looks similar, although perhaps not identical, to its full structure. For example, the leaf of a fern tree resembles the full plant and a river's tributary resembles the shape of the river itself.

Nature is full of fractal patterns; they can be seen in clouds, lightning bolts, crystals, snowflakes, mountains, and blood vessels. The fractal pattern of the cauliflower plant is ubiquitous and can be spotted in numerous living and non-living systems.

The properties of fractals, such as their shapes, sizes and relative positions, have been studied extensively; however, little is known about the processes involved in their formation.

To identify this, the researchers, from Comillas Pontifical University, Universidad Carlos III de Madrid, Instituto de Ciencia de Materiales-

CSIC, École Polytechnique and Katholieke Universiteit Leuven, firstly grew thin films using a technique known as chemical vapour deposition (CVD).

CVD is a technique used to grow a solid, in which a substrate is exposed to a number of precursors that react and/or decompose on its surface to create a specific thin film. The researchers tailored the CVD process so the film would grow into shapes similar to those seen on a cauliflower, but limited to the submicron scales.

From this the researchers were able to derive the formula which described how the cauliflower-like patterns develop over time. They proved that the formula was able to successfully predict the final cauliflower-like patterns by comparing them to actual cauliflower plants and combustion fronts, both of which occur at much larger scales.

Co-author of the paper, Mario Castro, said: "In spite of the widespread success of fractal geometry to describe natural and artificial fractal shapes, purely geometrical descriptions do not provide insight into the laws that govern the emergence of the shapes in time.

"We believe that by knowing the general laws that dictate how these patterns form and grow, it will help to identify the biological and physical mechanisms that are at play."

More information:
iopscience.iop.org/1367-2630/14/10/103039/article

Provided by Institute of Physics