Bacterium counteracts 'coffee ring effect'

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Credit: AI-generated image (disclaimer)

Ever notice how a dried coffee stain has a thicker outer rim, while the middle of the stain remains almost unsoiled? This 'coffee ring effect' also occurs in other materials. Researchers from the Departments of Chemical Engineering and Chemistry at KU Leuven have now discovered how to counteract coffee rings with 'surfactants', i.e. soap. The key to the discovery was not a kitchen towel, but a bacterium that counteracts the coffee ring effect at the microscopic level.

The findings were published in a recent edition of the leading journal *Nature Communications*.

When a coffee ring dries, its edges become noticeably darker and thicker. This occurs because the coffee particles move toward the edge of the stain while the water in the liquid evaporates. At a microscopic level, this coffee ring effect can also be seen in liquids with particles of other materials such as plastic and wood.

In various industrial applications – applying an even coat of paint or varnish, for example – the coffee ring effect can be particularly troublesome and scientists have long been seeking ways to counteract it. Raf De Dier and Wouter Sempels (Departments of Chemical Engineering and Chemistry) have now described a solution based on examples found in nature. De Dier and Sempels carried out experiments and calculations on nanomaterials as well as on a particularly promising bacterium, Pseudomonas aeruginosa.

Pseudomonas aeruginosa is a dangerous bacterium that can cause infections in open wounds. "A Pseudomonas aeruginosa bacteria colony wants to find as large a breeding ground as possible. To avoid overconcentration on the edges of a wound when spreading itself during the drying-out process, the bacterium produces substances that counteract the coffee ring effect."

These surface-tension-disrupting substances are called surfactants. Detergents such as soap are also surfactants. "Add soap to a stain – a coffee stain or any other stain –and you will still get a coffee ring effect. But at the same time the soap causes a counterflow from the edge back towards the centre of the stain in such a way that the small particles – material or bacteria – end up in a kind of whirlwind. In this way, you get a more uniform distribution of particles as evaporation occurs."

"If we genetically modify the bacteria so they can no longer produce surfactants, the coffee ring effect remains fully intact. Our findings on Pseudomonas aeruginosa also apply to other bacteria. For the biomedical sector, this study contributes primarily to our understanding of a biological system." But surfactants could also potentially be added to nanomaterials, and that makes De Dier and Sempels' findings interesting for industry. "Surfactants are inexpensive. It won't be long before we start seeing them turn up in industrial applications."

More information: www.nature.com/ncomms/journal/ … full/ncomms2746.html

Provided by KU Leuven