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Coffee Quality Measured by Electrochemistry

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For decades, the coffee industry has relied on optical refractometers to measure Total Dissolved Solids (TDS), which are used to assess coffee quality in terms of flavour, taste, and roast level. But this method has a major limitation as it measures only the cumulative refractive index of solutes and does not distinguish between different chemical compositions. A light roast and a dark roast, for example, can show the same value on a refractometer. That limitation may now be overcome by a new study published in *Nature Communications*.

Researchers led by R. E. Bumbaugh and co-workers[1] have developed an *in situ* electrochemical sensor that treats black coffee as a complex electrolyte. Using cyclic voltammetry, the team probed the electrochemical composition of coffee with a platinum working electrode acting as an "electronic tongue". The sensor was able to evaluate and classify coffee quality in terms of roasting strength, flavour, and taste.

The study showed that a cyclic voltammogram generated by sweeping the potential through the coffee sample can reveal both beverage strength and roast profile. At negative potentials, hydronium ions naturally present in coffee's organic acids undergo proton reduction on the platinum surface. This process corresponds to hydrogen underpotential deposition, a phenomenon well known on Pt electrodes in acidic media. By integrating the current over time during this phase, the researchers could determine the total charge passed, which scales linearly with the concentration of ingredients in the coffee matrix. The voltammogram also captured a second process linked to the adsorption of organic molecules. As the potential was cycled, surface-active compounds adsorbed onto the platinum electrode, blocking active catalytic sites and causing electrode fouling. The researchers found that the rate and magnitude of this current suppression provide a chemical fingerprint of the coffee sample. According to the study, darker roasts produced a stronger current decay than lighter roasts, reflecting chemical changes introduced during roasting. The authors also supported their interpretation with Quartz Crystal Microbalance studies, which measure nanoscale mass changes by tracking resonant frequency shifts. These measurements confirmed rapid mass accumulation on the platinum surface at negative potentials.

The researchers said the method showed commercial promise in a single-blind study with an industrial specialty roastery. This novel electrochemical approach could be extended to other beverages as a quality-testing tool.

Reference

1. Bumbaugh RE, Pennington DL, When LC, Rheingold EJ, Williams JR, Alemán BJ, Hendon CH. Direct electrochemical appraisal of black coffee quality using cyclic voltammetry. Nat Commun. 2026; 17:3618. https://doi.org/10.1038/s41467-026-71526-5

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