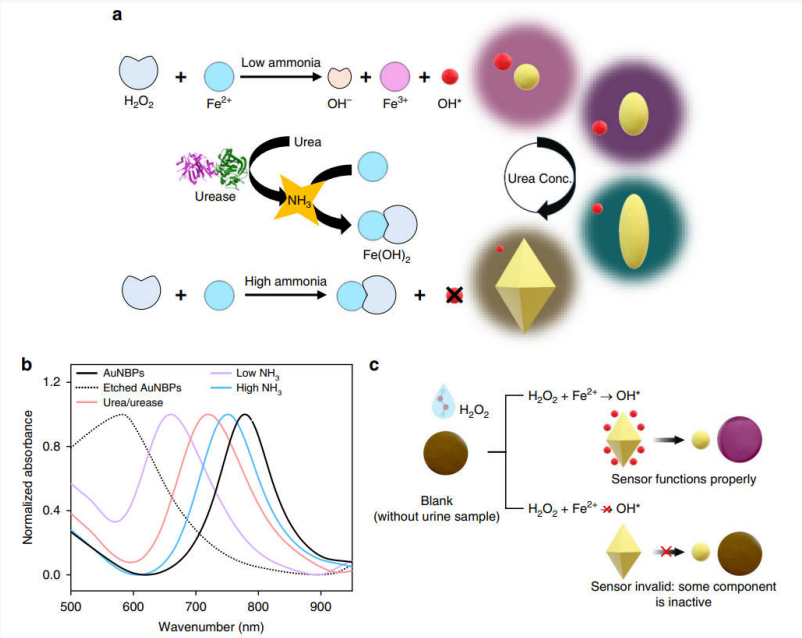
Seeing urea in color: a new way to detect disease at a glance

GA, UNITED STATES, August 1, 2025 /EINPresswire.com/ -- A team of researchers has developed a new biosensor that turns the invisible signals into visible color changes to detect urea levels in a simple way. The sensor works by combining gold nanoparticles and a pH-controlled reaction, with a special chemical reaction that changes color depending on the amount of urea. As more urea is present, the reaction slows down, and the gold nanoparticles keep their shape, resulting in a visible color shift. This enables a clear, multicolor visual cue across a wide concentration range. The sensor can detect urea down to 0.098 μM in solution and 0.2 μM in solid form. It significantly outperforms traditional methods and performed well in real urine samples, opening new possibilities for easy, accurate urea monitoring at the point of care.



Design and working principle of the multicolor urea biosensor.

Urea is a vital indicator of human health, particularly for diagnosing kidney and liver function. It is also widely used in agriculture, where overuse can lead to environmental contamination. While colorimetric tests are popular for their simplicity, most existing tools rely on single-color changes that are difficult to interpret by the naked eye, especially at low concentrations. More advanced methods, like fluorometry or electrochemical sensing, require complex equipment or training, limiting their accessibility. Improving the clarity and sensitivity of urea detection, especially through a visual and low-tech method—could bridge this gap. Due to these challenges, there is a growing need to develop multicolor sensors capable of intuitive, high-resolution readouts for both clinical and environmental use.

Scientists at Sungkyunkwan University, South Korea, have unveiled a multicolor biosensing platform for urea detection, published (DOI: 10.1038/s41378-025-00931-5) on June 5, 2025, in

Microsystems & Nanoengineering. The new sensor uses an enzyme called urease to break down urea to produce ammonia and raise the pH. This rise in pH prevents the chemical reaction that would normally change the gold nanoparticles. As a result, the particles keep their shape. Unlike conventional tests, this biosensor offers five visually distinct colors: blue, violet, purple, pink, and red, depending on the urea level. that can be read by the naked eye. The team validated the sensor's performance in both liquid and solid formats, paving the way for convenient, ultra-sensitive urea testing in clinical and field settings.

To make the sensor more practical and easier to handle, the team also developed a solid version using a gel by embedding the sensing chemistry into a hydrogel. This makes it easier to store and use. Both the liquid and solid versions worked well and were not affected by other substances in urine. The sensor's performance rivaled that of commercial urea kits, while offering the unique advantage of real-time, multicolor visual feedback. A built-in self-validation feature further ensures reliability by showing a clear color change only when all components function properly, making the sensor both powerful and foolproof.

“This sensor is not only technically advanced but also user-centric,” said Professor Dong-Hwan Kim, senior author of the study. “Its multicolor output allows anyone—even without lab training—to interpret results clearly and quickly. By controlling the Fenton etching through a simple pH shift, we've unlocked a highly tunable visual signal that outperforms many current diagnostic tools. We believe this is a significant step forward for point-of-care diagnostics, especially in resource-limited settings.”

This visually intuitive biosensor holds enormous potential for healthcare and environmental monitoring. Its solid-state format simplifies storage and usage, making it ideal for portable diagnostic kits, home testing, and rural clinics. In medical settings, the sensor can offer early warnings of kidney dysfunction or metabolic imbalance through simple urine analysis. In agriculture, it could be adapted for on-site detection of urea-based fertilizer runoff. Moreover, the underlying principle—pH-modulated nanoparticle etching—could be expanded to detect other analytes using similar strategies. With its combination of accuracy, ease of use, and multicolor feedback, this biosensor represents a meaningful leap toward accessible, next-generation diagnostics.

DOI
10.1038/s41378-025-00931-5

Original Source URL
https://doi.org/10.1038/s41378-025-00931-5

Funding information
This work was supported by the Institute for Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (RS-2023-00228994), RS-2024-00346003, and the National Research Foundation of Korea (2020R1A5A1018052) and

(RS-2024-00410209).

Lucy Wang
BioDesign Research
email us here