First rapid test for mpox developed, can be adapted for other emerging diseases

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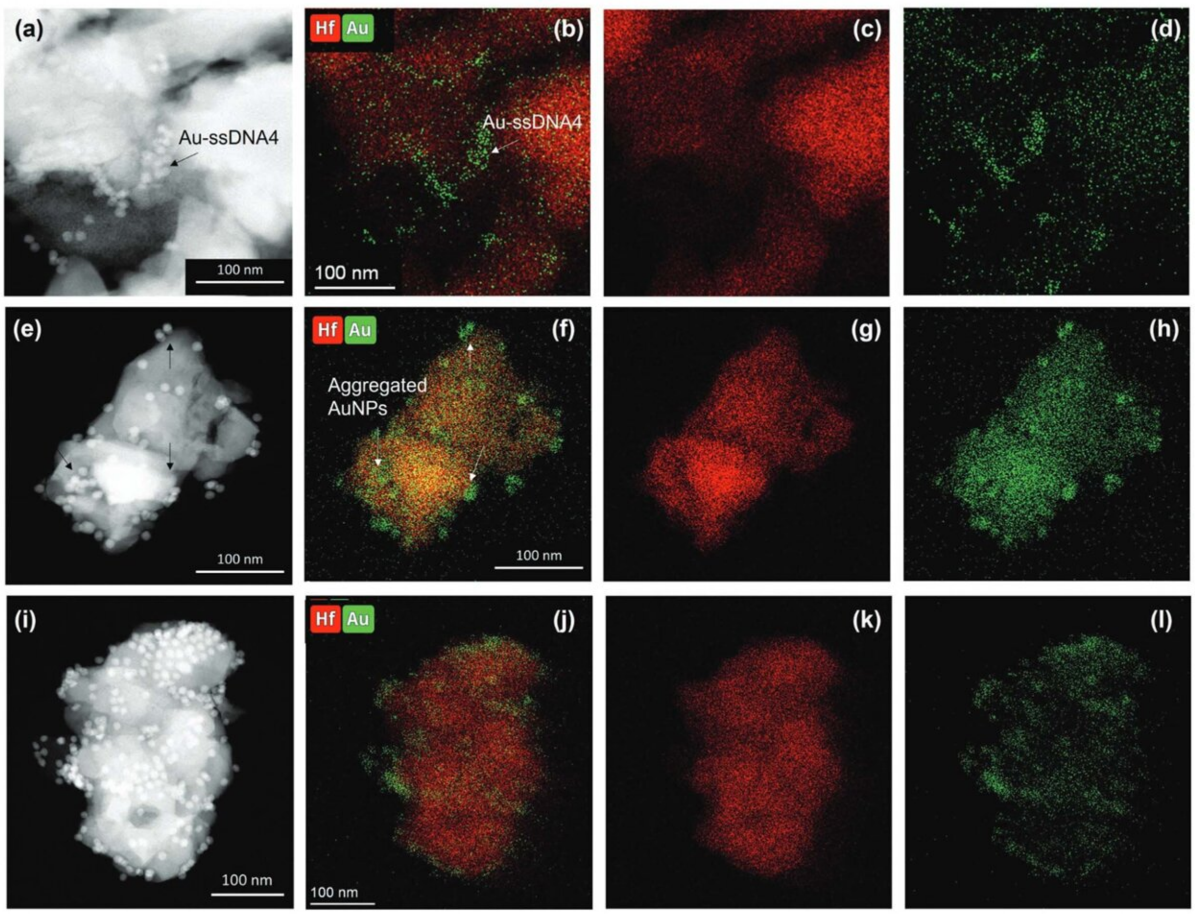

The nano-assembly mpox rapid test before (a) and after (e) the addition of mpox DNA. The red and green color encodes for gold nanoparticles and hafnium disulfide nanoplatelets respectively. The white arrows show dispersed gold nanoparticles and grouped gold nanoparticles. Credit: Dipanjan Pan

The first rapid test for mpox, more commonly known as monkeypox, has been developed by a team of researchers led by Penn State. The selective molecular sensor can detect the virus within minutes, without the use of any high-end instrumental techniques like polymerase chain reaction (PCR). Current tests require health care providers to swab lesions and send the samples to labs to be tested, which can take several days.

The technique, which was recently reported in the journal *Advanced Functional Materials*, uses nanomaterials heterostructures—zero-dimensional spherical gold nanoparticles and two-dimensional hafnium disulfide nanoplatelets—as building blocks to create a platform technology suitable for detecting trace amounts of genetic materials in biological samples.

"This is a major breakthrough in terms of how we manage the virus, as it is the first rapid test for mpox," said Dipanjan Pan, Penn State's Dorothy Foehr Huck & J. Lloyd Huck Chair Professor in Nanomedicine, who led the study. "While current caseloads are relatively low, as the weather warms and people become more active, cases could spike as they did last summer."

"But it's also important to note that this new technology can help us to prepare for the next epidemic or even pandemic," said Pan, who is also a professor of nuclear engineering and of materials science and engineering. "With slight modification of the molecules used for targeting the genetic sequences, we will be able to specifically detect other viruses, bacteria or fungi using the same method."

Dating back to the 1970s, the first human mpox case was identified in the Democratic Republic of Congo and was considered to be endemic only in Nigeria and some parts of central and west Africa. Since May of 2022, the virus has spread into more than 100 countries and caused over 86,900 infections across the world with approximately one-third of global cases concentrated in the United States.

Mpox virus is transmitted primarily through close physical contact and causes a disease with symptoms similar to smallpox, although less severe. A growing body of research from the Centers for Disease Control and Prevention shows people can spread mpox virus to others days before symptoms appear, making early detection via testing a critical tool to mitigate spread.

Currently, therapeutics and two-dose vaccines remain insufficient at stopping contagion, leaving rapid diagnosis as the only option for disease containment, Pan explained. PCR is the only available FDA-approved test known for mpox, despite its limitations of complex sample collection, transportation and insufficient access to advanced instrumental facilities. A rapid test, requiring only a small sample of lesion swab and short wait time for results, could dramatically slow the rate of transmission for the virus, he added.

"We were interested in developing a sensitive detection method for pathogens generally, and also wanted to apply the concept to an emerging pathogen like mpox, because there is a real-world urgency for this rapid nucleic acid test," Pan said. "There will be a significant impact on public health as a result of this technology."

The technology employs "plasmonic" nanoparticles, tiny metallic particles with unique optical properties due to their size and shape. In this case, the nanoscale metal particle is gold, which is refined to such a small scale that it is considered zero-dimensional. It is layered with hafnium disulfide, an inorganic, two-dimensional compound of hafnium and sulfur that is only a few atoms thick.

"There are many plasmonic tests for pathogens out there," Pan said. "But this is the first time we've demonstrated that a zero-dimensional plasmonic particle and two-dimensional nanoplatelets form a heterostructure that leads to enhancement of plasmon, which in turn offers an improvement in sensitivity."

The zero-dimensional gold nanoparticle and two-dimensional hafnium sulfide interact to form heterostructures that function as highly accurate sensors, with optical properties that change dramatically in the presence of external triggers, such as genetic material.

"Our work deals with plasmonics, which is the manipulation of light's flow using nanostructured metallic materials," Pan said. "Through the use of novel materials and chemistry, we are attempting to understand how these plasmon properties are manipulated to respond to various biological signals."

In this case, the signal was from trace amounts of viral DNA, specifically the conserved region of the mpox virus genome that is not subject to mutations. Nanoparticles have been used in the past to observe changes in biological systems, Pan said, but this is the first time two nanoscale objects in two different dimensions have been deployed to detect an emerging pathogen.

"This technique does not require expensive equipment or skilled personnel, and it can be tailored for future mutations or emerging pathogens," Pan said.

He explained that his lab is now testing the system against a panel of other pathogens to confirm its broad applicability for viral detection. Once the test is validated clinically, the lab will look for commercial partners to work with them to bring the technology to market, Pan added.

"Scientists strive to provide the public with cutting-edge, advanced technologies that enable them to self-diagnose or get diagnosed at the point of care," Pan said. "This is what we have done."

More information: Parikshit Moitra et al, Nucleotide-Driven Molecular Sensing of Monkeypox Virus Through Hierarchical Self-Assembly of 2D Hafnium Disulfide Nanoplatelets and Gold Nanospheres, *Advanced Functional Materials* (2023). DOI: 10.1002/adfm.202212569

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