SCIENCE AT THE ADVANCED PHOTON SOURCE

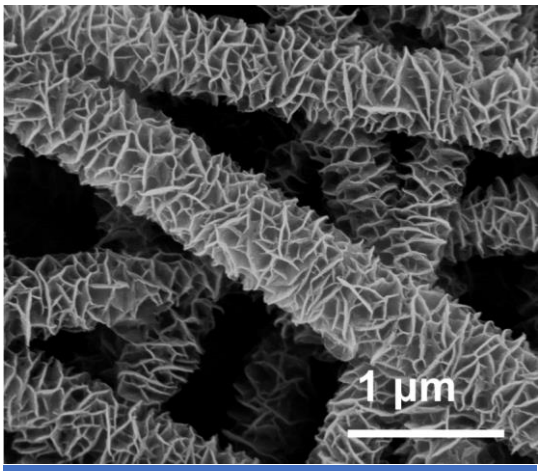
USING SIMPLE METHODS TO GROW A WIDE VARIETY OF NANOSHEET SUPERSTRUCTURES

Three-dimensional carbon superstructures are useful in a wide variety of applications, including batteries, catalysis and gas storage. Now scientists have come up with an easy and inexpensive way to make one- and two-dimensional versions of the same material.

Researchers found they could control the self-assembly of polyacrylonitrile (PAN) nanosheets into 1D nanofibers and 2D thin films. The team prepared a solution of acrylonitrile and azobisisobutyronitrile in acetone. They placed a substrate that had been treated with oxygen plasma, such as a silicon wafer, into the solution, then heated it to 70°C. A series of nanosheets formed on top of the wafer, growing roughly perpendicular to the surface.

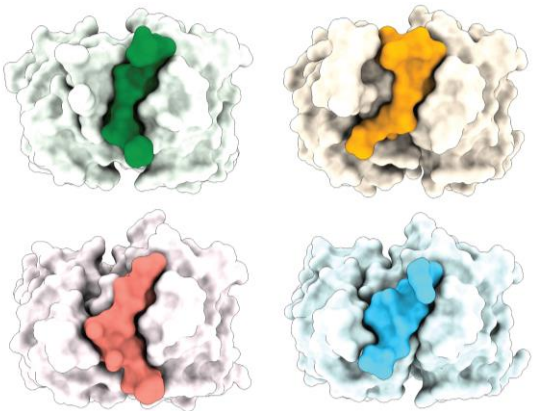
To grow 1D nanofibers, the scientists used a similar process, but instead of a flat wafer as the substrate they used an existing nanofiber. Researchers took nanofiber that had been created through the electrospinning process, heated it to 250°C to stabilize it, and placed it in the solution. PAN nanosheets grew on the surface of the bare nanofibers, forming new nanofibers with nanostructures determined by the growth conditions.

To see what their nanomaterials looked like, the team performed ultra-small-angle X-ray scattering studies at beamline 20-ID-B at the Advanced Photon Source (APS). That allowed them to see the structure at a scale from micrometers down to nanometers and make quantitative measurements of that structure. It also allowed them to see inside the materials and to identify structures such as microvoids in the fibers.



Nanostructured PAN nanofibers are shown in a scanning electron microscope image

H. Gong, et. al. "Tunable 1D and 2D polyacrylonitrile nanosheet superstructures," *ACS Nano* 2023, **17**, 18, 18392-18401
https://doi.org/10.1021/acsnano.3c05792



Four different binding modes characterized by the research team. Antibody binding alters the shape of the PfCSP antigen to fit in the antibody binding pocket. Four different antibodies are shown here in pale colors, bound to PfCSP antigen peptides, colored in green, orange, pink and blue.

E. Thai et. al., "Molecular determinants of cross-reactivity and potency by VH3-33 antibodies against the Plasmodium falciparum circumsporozoite protein," *Cell Reports* 42, 11
https://doi.org/10.1016/j.celrep.2023.113330

FINDING THE KEY TO A MALARIA VACCINE

The past two decades have seen approximately 240 million reported cases of malaria annually, signaling a desperate need for an effective malaria vaccine.

In this study, the researchers aimed to assess the efficacy of antibodies encoded by the *IGHV3-33* gene. These antibodies are highly prevalent in the immune response against Pf circumsporozoite protein (PfCSP)—the most abundant surface protein on the deadliest malarial parasite, *Plasmodium falciparum*, and the antigen used here.

The team solved 22 crystal structures of 12 antibodies bound to PfCSP peptides, using beamlines 23-ID-B and 23-ID-D at the APS. The trove of data revealed that the antibodies bound to the antigen in four different binding modes. That means numerous antibodies can recognize and cluster around different motifs in a single antigen. In this unusual way, the antibodies carry high inhibition.

The plethora of crystal structures revealed a surprising diversity within this antibody family, giving it numerous different binding profiles. One antibody with a particularly unique binding mode that hadn't been observed in any previous studies had high inhibition even though it had low cross-reactivity. This indicates that there is still more to learn about how different antibodies target the PfCSP antigen to inhibit the malaria parasite.

Read more on these and other highlights at aps.anl.gov

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Advanced Photon Source
Bldg. 401
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL, 60439

aps.anl.gov
aps.anl.gov/APS-Upgrade
apsinfo@aps.anl.gov