New glue sticks easily, holds strongly, and is a gas to pull apart

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A temporary adhesive based on molecular solids is strong enough to hold a chemistry PhD candidate, but can be released without force through the use of heat in a vacuum. Credit: Nicholas Blelloch

Temporary glues may not steal headlines, but they can make everyday life easier.

Sticky office notes, bandage strips and painter's tape are all examples of products that adhere to surfaces but can be removed with relative ease.

There's only one drawback. To remove any of those adhesives, the glued surfaces need to be pulled apart from each other.

Dartmouth research has discovered a class of molecular materials that can be used to make temporary adhesives that don't require force for removal. These non-permanent glues won't be available as home or office supplies, but they can lead to new manufacturing techniques and pharmaceutical design.

"This temporary adhesive works in an entirely different way than other adhesives," said Katherine Mirica, an assistant professor of chemistry at Dartmouth. "This innovation will unlock new manufacturing strategies where on-demand release from adhesion is required."

The Dartmouth research focuses on molecular solids, a special class of adhesive materials that exist as crystals. The molecules in the structures are sublimable, meaning that they shift directly from a solid to a gas without passing through a liquid phase.

The ability to bypass the liquid phase is the key to the new type of temporary adhesives. The adhesive sticks as a solid but then turns to a vapor and releases once it is heated in a vacuum environment.

"The use of sublimation—the direct transition from solid to vapor—is valuable because it offers gentle release from adhesion without the use of solvent or mechanical force," said Mirica.

Previous Dartmouth research was the first to identify how molecular solids can act as temporary adhesives. According to new research, published in the academic journal *Chemistry of Materials*, the class of molecules that can be used to make these new-generation materials is wider than previously thought.

"We've expanded the list of molecules that can be used as temporary adhesives," said Nicholas Blelloch, a Ph.D. candidate at Dartmouth and first author of the paper. "Identifying more materials to work with is important because it offers expanded design strategies for bonding surfaces together."

The research team says the new temporary adhesives can be useful in technical applications such as semiconductor manufacturing and drug development.

When making computer chips, silicon components need to be temporarily bonded. The use of a strong adhesive that releases through sublimation can allow for the development of smaller, more powerful chips since tapes requiring forceful pulling would no longer be required.

In pharmaceuticals, the design principles highlighted through this work can help the development of smaller, faster-acting pills. The adhesives can also be helpful in the design of nano- and micromechanical devices where the use of tape is not possible.

The finding also gives researchers more flexibility in developing temporary adhesives.

"Identifying more molecules with adhesives properties refines our fundamental understating of the multi-scale and multi-faceted factors that contribute to the adhesive properties of the system," said Blelloch

Most common temporary adhesives that are used in the home or office are polymers, long chemical chains that create strong bonds, but can be difficult to be pulled from surfaces.

If polymers can be described as long chemical strands that easily tangle, molecular solids are more like individual chemical beads that sit atop each other. Both can be made to adhere, but there are tradeoffs.

Polymers used to make super glues tangle so well that they form exceedingly strong bonds that are difficult to pull apart. Sticky office notes and painter's tape are also polymers, but with much less holding strength. They also require a peeling or ripping action to remove the bond.

Molecular solids being studied by the Dartmouth team can be as strong as temporary, polymer-based adhesives. The advantage of the new glues is that they not only adhere easily, they can be released without force, and without disturbing the bonded surfaces.

More information: Nicholas D. Blelloch et al, Crystal Engineering of Molecular Solids as Temporary Adhesives, *Chemistry of Materials* (2020). DOI: 10.1021/acs.chemmater.0c01401

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