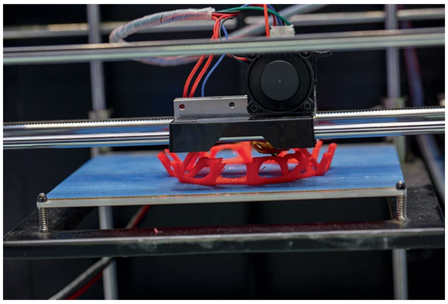
The ebb and flow of 3D printing

The ability to make precise materials rapidly and at low cost has enabled the growth of the 3D printer market. To tailor products, the flow of materials as well as the assembly pathway are key considerations.

3D printers are common in laboratories and now increasingly so in our homes, as they become more affordable and useful for printing everyday objects. This type of additive manufacturing builds up a macroscale material in a layer-by-layer manner using a computer-aided design (CAD) package. The commercial applications of 3D-printed materials are also more prevalent and include biomedical uses, laboratory equipment or even large-scale infrastructure such as houses.

The low cost and relatively high speed of production makes 3D printing an attractive way to create macroscale materials. In addition, although a 3D printer needs energy to run, solar cells can power the printer and waste plastics can be recycled as the input material, making the technique a sustainable option. Moreover, some CAD packages are freely available to download from various sources, which opens up the technique to those without a high level of programming knowledge and keeps fabrication costs low.

Considering we are only in the fifth decade since the conception of the 3D printer, the breadth of 3D-printed materials of different chemical compositions made with an infinitesimal number of errors is vast. However, it is not just the chemistry of the reagents which influences the properties of the final material, but also the flow of the materials throughout the printing process and assembly pathway to make the product.



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Writing in a Perspective in this issue, Davidson and co-authors, focus on the rheological requirements for making 3D-printed materials, and discuss how 3D printing can fabricate out-of-equilibrium systems and stimuli-responsive materials. In rheological terms, materials must show shear-thinning behaviour to flow and change from liquid-like to solid-like when leaving the nozzle of the printer. These flow behaviours are tunable, to a certain extent, by the microstructure of the material. This structure may comprise networks that disrupt under stress and flow, only to reform when flow ceases and the material solidifies. Or printability can be achieved by incorporating dynamic bonds in the material, which has the advantage of eliminating the use of fillers, but the mechanical properties of such printed materials can suffer.

Out-of-equilibrium processing is possible using 3D printing techniques and occurs when the materials are trapped in a metastable structure. As highlighted in the Perspective, the ordering of helical liquid crystals can be suppressed under shear, resulting in more planar backbones, which in this case leads to improved charge transport properties. In another example, bottlebrush copolymers with structural colour can be trapped to give specific local arrangements of colour.

Davidson and co-authors envision that the future of additive manufacturing of soft matter will feature the use of materials bespoke for such processing. The hope is that these custom-made materials will achieve the desired processing pathway by offering the optimal chemical and physical properties to enable high-quality printing.

At *Nature Synthesis*, we are interested to hear about your research advances in processing in all areas of chemistry and material science, not just those related to additive manufacturing. Such innovations may include significant advances in the technical features of processing routes resulting in useful end products, as well as the chemical compositions and microstructures that are the best fit for enabling reproducible and high-quality products, ideally in a sustainable way.

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