TRIBOELECTRICITY

Soft power

Sci. Adv. **3**, e1700015 (2017)

Power generation from body movement in an energy harvester entails stable performance over long periods of time under variable mechanical strain. A triboelectric nanogenerator (TENG) — a device that converts mechanical energy into electricity — is naturally flexible and, thus, has the ability to fulfil the required functionality. Now, Pu *et al.* have fabricated a soft and ultrastretchable on-skin triboelectric nanogenerator (STENG) that can simultaneously serve as a tactile sensor and energy harvester.

Unlike a conventional TENG designed with electrical conductors, the electrode of its skin-like analogue is composed of ionic hydrogel. In a typical STENG, a layer of PAAm-LiCl hydrogel is sandwiched between PDMS or VHB elastomer films that serve as electrification layers. The devices are nearly transparent in the visible range, biocompatible and can be stretched to more than ten times their original length without rupturing. The electrical performance doesn't show any signs of degradation after thousands of long-term motion cycles. The encapsulation of the hydrogel by the elastomers prevents its dehydration, preserving the device functionality in the temperature range of 0–60 °C. The on-skin generators are capable of producing an open-circuit voltage of 145 V and a power density of 36 mW m^{-2}. Apart from the ability to harvest biomechanical energy, STENGs can serve as touch sensors, sensing pressure of as low as 1.3 kPa. *OB*

CARBON NANOSTRUCTURES

Graphene-packed fullerene

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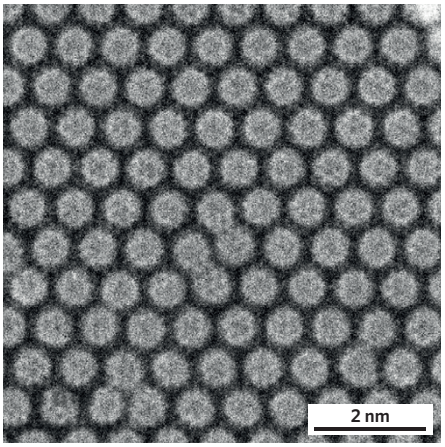

AAAS

C_{60} fullerene molecules are usually encapsulated before studying their dynamical properties and mutual bonding by means of electron microscopy. For this aim, a successful strategy is the use of carbon nanotubes to wrap buckyball molecules in a peapod-like configuration. Among the several advantages of this approach — such as the high localization accuracy — a clear drawback is the constraint along one single spatial dimension. In fact, free fullerene molecules on surfaces can self-assemble in two-dimensional configurations.

Now Mirzayev, Mustonen and colleagues report on the encapsulation of C_{60} molecules in two monolayer graphene sheets at room temperature. Within these suspended hybrid structures, which are visualized by means of high-resolution scanning tunnelling electron microscopy, the researchers observe wide areas where the buckyballs are arranged in a stable single-layer hexagonal close packed lattice. Still, isolated buckyballs rotate steadily while diffusive effects are observed at the lattice edges.

Aside from maintaining a stable spatial configuration, graphene offers an effective protecting layer against the possible modifications induced by the electron beam in the molecules. Yet, the researchers observe beam-induced knock-on damage and the generation of intermolecular bonds. They also report that high degrees of dimerization suppress the tendency for the single molecules to rotate freely — peanut-like clusters tend to rotate around their joint axis, while triangular clusters do not rotate at all. *GP*

DRUG DELIVERY

Hitching a platelet ride

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The plasma protein factor VIII (fVIII) is an essential blood clotting agent that is defective or absent in hemophilia-A patients. Systemic injection of fVIII is used to promote blood coagulation in patients, but in 30% of the cases this strategy fails due to the formation of anti-fVIII antibodies during the treatment.

In their work, Hansen *et al.* design an alternative strategy for targeted delivery of fVIII, with platelets serving as vehicles for the transport of a fVIII-loaded polyelectrolyte multilayer capsule. The outermost layer of the capsule is composed of fibrinogen for facile hybridization with the platelets. While in other drug delivery approaches an external stimulus induces cargo release, in this case it is the contraction of the platelets, which naturally occurs upon cell activation at the injury site, that triggers release of the drug.

Using a microfluidic vascular injury model and a well plate assay to monitor clotting, the researchers show that their hybridized system shields fVIII from the environment, reducing formation of anti-fVIII antibodies, and demonstrate that the mechanical force created by platelet contraction induces the capsule to burst and deliver the cargo at the injury site. They also measure increased concentration of fibrin, a protein involved in the coagulation process, both in healthy and in fVIII-depleted blood, and reduced blood clotting time, compared with systemic delivery of fVIII.

Finally, while they present their approach as a therapeutic strategy for hemophilia-A, they also suggest that it could be extended to other pathological platelet-mediated conditions such as thrombosis, infections and cancers. *CP*

ADENOSINE TRIPHOSPHATE

More than an energy source

Science **356,** 753–756 (2017)

Aside from being an energy source, adenosine triphosphate (ATP) can also act as a biological hydrotrope, as Patel *et al.* now report. At millimolar-level physiological concentration, ATP can keep proteins soluble and dissolve the preformed protein fibres. This finding also explains why the cytoplasmic ATP concentration is so high, up to 5 mM; much more than enough to meet energy needs at the micromolar level.

Patel *et al.* verify the boosting effect of ATP on protein solubility by testing the liquid compartment formed by purified fused in sarcoma and two proteins that tend to form amyloid fibres. Furthermore, they confirm the stabilization effect of ATP on egg-white protein under boiling conditions. The control experiments reveal that the adenosine ring in ATP enhances the protein stabilization effect of the charged tripolyphosphate moiety by facilitating the binding/clustering between the aromatic ring of ATP and hydrophobic proteins. GTP, ADP and AMP achieve the same enhancement effect while their concentrations *in vivo* are quite low, thus their effects can be negligible. The physiological concentration of ATP helps to maintain the high concentration of proteins (around 100 mg ml^{-1}) in cells, beyond the value at which they would aggregate in test tubes. *WS*

Written by Olga Bubnova, Chiara Pastore, Giacomo Prando and Wenjie Sun.