Strong bioinspired HPA–rGO nanocomposite films via interfacial interactions for flexible supercapacitors

Inspired by the interfacial interaction design of natural nacre, we described an effective and novel strategy to assemble halloysite–polyaniline–graphene oxide (HPA–GO) nanocomposite films via synergistic interfacial interactions of π–π conjugated bonds, hydrogen bonding, and electrostatic interaction. The achieved HPA–rGO nanocomposite films show excellent tensile strength, toughness, and high electrical conductivity. These bioinspired electrodes with excellent mechanical properties offer an opportunity for the next-generation flexible power source in the fields of aerospace, smart electronics, and other portable devices.
<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>p2</td>
<td>NEWS</td>
<td>The 7th Beihang University Vision Forum for International Young Scholars–Choosing Your Destination and Joining Us in Building a Better Future</td>
</tr>
<tr>
<td>p4</td>
<td>RESEARCH highlights</td>
<td>Basic medical research and targeted therapy application of multi-mode driven microrobot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fiber optic-based laser interferometry array for three dimensional ultrasound sensing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research progress in energy fields assisted microforming technologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiscale and multiphysics modeling techniques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ab initio/transition-state theory study of the reactions of $\text{C}_5\text{H}_9$ species of relevance to 1,3-pentadiene, part I: potential energy surfaces, thermochemistry, and high-pressure limiting rate constants</td>
</tr>
<tr>
<td>p18</td>
<td>COVER story</td>
<td>Strong bioinspired HPA-rGO nanocomposite films via interfacial interactions for flexible supercapacitors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inspired by the interfacial interaction design of natural nacre, we described an effective and novel strategy to assemble halloysite-polyaniline-graphene oxide (HPA-GO) nanocomposite films via synergistic interfacial interactions of π-π conjugated bonds, hydrogen bonding, and electrostatic interaction. The achieved HPA+rGO nanocomposite films show excellent tensile strength, toughness, and high electrical conductivity. These bioinspired electrodes with excellent mechanical properties offer an opportunity for the next-generation flexible power source in the fields of aerospace, smart electronics, and other portable devices.</td>
</tr>
<tr>
<td>p20</td>
<td>FEATURE focus</td>
<td>Multi-wall Sn/$\text{SnO}_2$@Carbon hollow nanofibers anode material for high-rate and long-life lithium-ion batteries</td>
</tr>
<tr>
<td>p23</td>
<td>INSPIRATION</td>
<td>Cheers and roses from undergrads for Yale’s Nobel laureate</td>
</tr>
</tbody>
</table>
MESSAGE FROM UNIVERSITY LEADERSHIP

The tide of the world is surging forward, and we should keep up with the times. The future has come. In 2020, the building of a moderately prosperous society in all respects is key to reaching the first of the Two Centennial Goals. Decisive progress has been made in the fight against poverty, and our country is winning battle against poverty. Riding the wave in a new era and standing at a critical junction in history, each one of us is witness of the great history and can be creator as we enter a new epoch. Let us seize the day and live it to the full–racing against time and treasuring each day. Let us closely unite around the CPC Central Committee with Comrade Xi Jinping as the core. Be united and put more energy into our work–cultivating high-quality talent and making significant contributions. Towards building a world-class university with Chinese characteristics, let us catch the wind and set sail in the direction of our dreams.

Beihang University
Secretary of the CPC Committee Cao Shumin and President Xu Huibin
The 7th Beihang University Vision Forum for International Young Scholars—Choosing Your Destination and Joining Us in Building a Better Future

The 7th Vision Forum for International Young Scholars opened on December 21, 2019 in the Vision International Cultural Exchange Center. Sponsored by Beihang University and organized by the Human Resource Department, the Talent Management Center, and the International Research Institute for Multidisciplinary Science, the Forum brings together 180 young scholars from reputable universities and research institutions including the University of Cambridge, Stanford University, Yale University, National University of Singapore, and Purdue University.

The opening ceremony, hosted by Vice Director of Human Resources Zhuang Yan, had speakers including Vice President Wang Yunpeng. Scientists and scholars with titles of honor, as well as Deans and Secretaries of some of the University’s Schools attended the opening session.

Vice President Wang Yunpeng, in his opening speech, congratulated on the opening of the Forum, and extended greetings to the young scholars from around the world. He said that Beihang is a university recognized for its pioneering work and advancement of ideas, and for patriotism—a university whose fate is believed to be connected with the motherland.
In recent years, the University has been deepening the reform of personnel system, introducing classification management of personnel (setting position classification standards and determining the occupational series, title, grade, and pay system) and making efforts to improve evaluation standards. The University is also building a global talent network in the hope of recruiting the best talent. The University will further improve the effectiveness of its three-level responsibility system involving the University, the Schools and the research teams to better recruit and cultivate talented faculty members and to provide support.

In his speech, HR Director and Head of Section on Faculty Morality and Integrity Tan Hualin, in retrospect, spoke of great changes that took place since the University’s founding in 1952, the course of development of its subject areas, achievements, and future plans. The University has been cultivating talent with scientific and technological innovation. “Through enhancing quality, building platforms, putting forward new measures, and providing support through coordination of resources, we are making solid progress in the construction of talent teams, thus giving full support to the University’s talent cultivation, subject development and science and technology innovation”. He sincerely welcomes talented young people to join the faculty of Beihang.

During the opening session, three academic talks were given by Professor Yang Lijun, Professor Liu Mingjie and Associate Professor Hou Huilong on the subjects of “challenges in research of large liquid rocket engines”, “bio-inspired functional polymer gels”, and “the latest research progress of solid-state elastocaloric cooling technology and its applications in aerospace”.

Seven parallel subforums in Mathematics and physics, Engineering sciences, Aeronautics & Astronautics, Chemistry and materials science, Information science, Economics, management and business, and Interdisciplinary medicine and engineering were held in the afternoon for the scholars to have in-depth discussions around cutting-edge science and technology, promoting academic exchanges and cooperation among young scholars through presentations and discussion of academic issues.

The Forum successfully concluded on December 23, 2019. More than 700 young scholars from leading universities and research institutions around the world submitted applications. Both the number of scholars who applied and the number of scholars who were invited to attend the Forum reached a record high. The Schools, Institutes, and the working group for the establishment of a Sino-French aviation college organized a series of activities including meetings and campus visits. During the Forum, the Human Resource Department also conducted a talent review meeting for the “Zhuoyue” recruitment and management program, implementing the University’s strategies of talent team construction through selection of outstanding young scholars.

(Text by Wang Rui)
Basic medical research and targeted therapy application of multi-mode driven microrobot

Cancer is a major problem that has not yet been overcome in the history of human diseases. According to statistics, the number of cancer patients in China has exceeded 10 million, and the number of new patients has increased to nearly 4 million per year. As a means of systemic therapy, chemotherapy has the disadvantages of poor drug targeting and large side effects. In recent years, targeted drug technology has made great progress, but the lack of universality, passive targeting and low efficiency have limited the further development of precision treatment.

The rapid development of micro-nano technology and materials science provides new solutions for precise treatment. As a drug carrier, micro-nano robots controlled by precise magnetic field are expected to achieve drug delivery and cell grasping. In the fields of cell biology and regenerative medicine, the precise operation of cell-level organization is extremely important.

Magnetic control system for micromanipulation has become the first choice for in vivo navigation and micromanipulation due to its large working space, large operating force, little influence on biological tissues, and no need for external energy input lines and control lines. As shown in Fig 1 (a), the magnetic control system of the spatial multi-coil can control the motion of the microrobot and display the microrobot’s real-time position in the meantime, and Fig 1 (b) is a diagram of the actual system. The magnetic octopus-like microrobot shown in Fig 1 (c) can realize three-dimensional motion in the working space. Fig 1 (d) is an in vitro experimental diagram of tumor therapy using a magnetic system to operate a “cell robot”.

The permanent magnetic tools for cell manipulation have been widely used in the fields of cell cloning and single cell analysis. The use of permanent magnet tools will enable high-throughput, fully automated operation of cells. As shown in Fig 2 (a), the external permanent magnet actuates the magnetic microrobot to achieve precise motion on a chip. As shown in Fig 2 (b), the magnetic control system simultaneously introduces ultrasonic vibration of the
piezoelectric ceramic to reduce the friction between the microrobot and the substrate. The system has achieved superhigh control precision of up to 300 nm. Fig 2 (c) shows various magnetic microrobots, and Fig 2 (d) shows the rotation operation of oocytes using a microrobot. Fig 2 (e) is the combination of micro-robots with a microfluidic chip.

The photoelectric iridium system for micromanipulation has submicron control accuracy and the possibility of controlling the target group, as shown in Fig 3 (a), the working principle of the spot diaphragm. Optoelectronic Tweezers (OET) is a new manipulation technology that combines aperture and dielectrophoresis to produce dynamic optical virtual electrodes for more complex manipulation of particles. Fig 3 (b) shows the actual optical path structure. Fig 3 (c) shows the operation of the OET through the iPad. Fig 3 (d) shows the particle handling by the OET. Fig 3 (e) shows the OET manipulated particles.

The soundwave-drive operating system has the characteristics of large output force, no damage to biological tissues, and simple system. By changing the shape of the structure to produce different types of micro-acoustic flow, cell-level precision operations such as cell capture, cell handling, and cell rotation can be achieved. Fig 4 (a) is the schematic diagram of the acoustic flow drive system. Fig 4 (b) shows the function of acoustic flow. Fig 4 (c) shows the experiment result that confirms the rapid and accurate ultrasound on rotating the cells.

The development of micro-nano robot technology is increasingly showing the trend of precision, intelligence and multi-functions. With the goal of
Fig 4. Acoustic-driven operating system

Lin Feng’s research is in the fields of micro- and nano-robotics and its application to micro- and nano-assembly and cell manipulation, bio-automation systems, medical robotic systems, micro and nano electro mechanical systems, and intelligent robotic systems. Prof. Feng’s Bionic and Micro-Nano System Laboratory participated in a number of major research projects and won several awards of the International Robotics and Micro-Nano Society. He has published more than 60 papers in the field of micro-nano systems and machinery. In February, 2016, he published innovative research results in *International Journal of Robotics Research*, a top journal in the field of robotics.

References


Fiber optic-based laser interferometry array for three dimensional ultrasound sensing

Ultrasound imaging has been widely used in medical diagnosis due to its non-invasive, radiation-free, and real-time features. Three-dimensional (3D) sensing enables the recovery of the location and velocity of the acoustic source. Traditionally, piezoelectric materials were used for the transduction between acoustic wave and electrical wave. In recent years, resonance based optical sensing of ultrasound (F-P cavity, micro-ring, etc.) has demonstrated very high sensitivity and broad bandwidth with compact size. Besides, the optic sensing modality is immune to electromagnetic interference. However, they need to operate in specific wavelengths or angles, which restricts their application in array sensing. Non-resonance-based optical sensing arrays did not perform sufficient bandwidth or frame rate.

Here, we propose a fiber optical-based ultrasound sensing array with relatively high sensitivity, wide bandwidth, and three dimensional (3D) sensing capabilities, which is potentially useful in medical imaging. The laser interferometry system consists of a continuous wave 1310 nm laser, a seven-channel sensing array, a Bragg cell for frequency shifting, two 1 × 8 optical couplers, seven channels of rotator, 2 × 1 coupler, photo diodes, amplifiers, and an array data acquisition system (Fig 1). The 1310 nm laser was split to eight channels, one as the reference and the other seven channels for sensing. Frequency of the light beam in the reference channel was increased by 40 MHz using an acousto-optic modulator. The reference beam was then split to seven channels to interfere with the sensing beams, generating a frequency modulated signal exhibited as variation of light intensity. The light variation signal was collected by a photo diode in each interference channel, which was further amplified, digitized, and demodulated in a computer.

Commercial hydrophone HGL-0200 from Onda, one of the top hydrophone companies, was used as a comparison with our sensor. The HGL0200 performs very well with all the parameters balanced. The sensitivity of the hydrophone is 50 nV/Pa, and the bandwidth is over 60 MHz. Photoacoustic signal from 10 ns laser pulse was used as the acoustic source to evaluate the two acoustic sensors. According to the experiment, the proposed sensor exhibited better performance than the hydrophone (Table 1 and Fig 2).

In the localization of an acoustic source, the radial distance $r$ indicates the distance from the sound source to

<table>
<thead>
<tr>
<th>Noise-equivalent pressure</th>
<th>HGL-0200 hydrophone</th>
<th>Fiber-optic array sensor</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.7 kPa</td>
<td>165 Pa</td>
<td>Lower is better.</td>
<td></td>
</tr>
<tr>
<td>Electromagnetic interference</td>
<td>16.4 kPa</td>
<td>None</td>
<td>Lower is better.</td>
</tr>
<tr>
<td>-6 dB bandwidth</td>
<td>0.7 – 26.8 MHz</td>
<td>0 – 27.2 MHz</td>
<td>Wider is better. Limited by the source</td>
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<tr>
<td>Signal-to-noise ratio</td>
<td>23.5 dB</td>
<td>46.8 dB</td>
<td>Higher is better.</td>
</tr>
</tbody>
</table>
the sensor, the polar angle $\theta$ indicates the deviation from the axial axis, and the azimuthal angle $\phi$ indicates the rotational dimension around the z axis (Fig 3 a). Because the seven-element sensor was rotational symmetry of order 6 in the azimuthal dimension, a measurement range of $0^\circ$ – $60^\circ$ was sufficient to cover the whole dimension. The localization errors in the 3D coordinate are illustrated in Table 2 and Fig 3.

In conclusion, the optical ultrasound sensor exhibited significantly higher sensitivity and broader bandwidth than traditional hydrophone. Furthermore, the multi-core fiber acted as a seven-element 2D array, which enabled relatively precise 3D sensing capability. Therefore, the miniature 2D array holds great potential for high resolution and weak signal detection in medical ultrasound imaging.

In addition, the system did not rely on any sophisticated micro-fabrication procedure or fine tuning of laser wavelength. This work is published in *Optics Letters*, a top journal in optics.
Research progress in energy fields assisted microforming technologies

Micro-nano manufacturing is a key technology in the fabrication sectors, which represents the forefront of the manufacturing science. As an advanced micro-nano manufacturing technology, microforming has various advantages including low cost, high efficiency and desirable workpiece performance, and has been widely used in the fabrication of micro-weapon, micro-satellite, medical equipment, heat exchangers and other microproducts. However, with the increasingly prominent problems of environmental pollution and energy shortage, the requirements for both shape and performance of microparts grow rapidly, and the traditional microforming technology cannot meet the needs of synergetic manufacturing of difficult-to-deform microcomponents. Recently, the novel microforming process assisted by energy fields, such as ultrasonic vibration, pulsed current, laser and electromagnetic, has been gradually developed, which is considered a beneficial way to achieve the green, efficient and precise manufacturing of high-performance microparts.

For ultrasonic vibration aided microforming, the research team investigated the deformation characteristic of Inconel 718 ultrathin sheets under ultrasonic vibration field with diverse amplitudes. The microscopic mechanism of ultrasonic softening effect was analyzed, and it is proved that the ultrasonic vibration can promote the twinning deformation and grain rotation. A constitutive model considering grain size effect and ultrasonic softening was developed, which is able to predict the deformation behavior of ultrathin sheets with a relative error less than 0.5%, as shown in Fig 1 (a) and (b) [1]. Furthermore, the ultrasonic aided forming method was employed in the fabrication of superalloy microtube with the outer diameter of 0.9 mm and wall thickness of 50 μm, as indicated in Fig 1 (c). With the assistance of ultrasonic vibration, the forming force...
was reduced, the dimensional accuracy and the uniformity of wall thickness were enhanced, and the surface quality was improved. The research has been published in *International Journal of Mechanical Sciences*.

For electrically assisted microforming, the research team explored the deformation behavior of ultrathin superalloy sheets under different current densities. It was demonstrated that the material flow stress is decreased with the increase of current intensity while the elongation is slightly changed. On the other hand, the dynamic strain aging is enhanced, which is attributed to the dislocation pinning effect activated by pulsed current. Besides, the dislocation is directionality distributed with the assistance of pulsed current. Based on the macroscopic analysis, a dislocation density based constitutive model considering the electric field was established, as shown in Fig 2 (a) and (b)[2]. Furthermore, the electrically assisted drawing and pulsed current treatment were applied to the fabrication of thin-walled superalloy capillary, which effectively promotes the dynamic recrystallization, improves the ductility and refines grains of the superalloy capillary, thus solving the manufacturing issues like uneven thickness distribution and coarse grain, as shown in Fig 2 (c)[3]. The research has been published in *Materials Science and Engineering: A*.

Based on the compound manufacturing technology that couples ultrasonic vibration and pulsed current field, the precise control of shape and performance of the thin-walled superalloy capillary was realized. The micro tubular products have been adopted to constitute the prototype of compact heat exchanger for hypersonic precooled airbreathing propulsion, as shown in Fig 3.

For the development of high-performance micro medical devices, the superplastic microforming technology was proposed to create the Zn-Mg microtube, which is used as feedstock for vascular stent. The superplastic forming technology can reduce the forming passes, providing basis for the development of a new generation high-quality vascular stent, as shown in Fig 4 (a) and (b)[4]. In addition, the research team carried out the thermal aided microforming experiment to efficiently fabricate the titanium dental abutment, in which the fabricating quality was controlled by forming temperature, as shown in Fig 4 (c). The research results have been published in *Materials & Design*. 

![Fig 1. (a) Ultrasonic aided microforming system; (b) Stress-strain curves under ultrasonic vibration; (c) Ultrasonic assisted tube drawing](image1)

![Fig 2. (a) Dislocation evolution during electrically assisted forming; (b) Constitutive behavior and prediction results; (c) Section view of thin-walled superalloy capillary](image2)
Fig 3. Compact heat exchanger for hypersonic precooled airbreathing propulsion

Fig 4. (a) Superplastic behavior of Zn-Mg alloy; (b) Manufacturing of Zn-Mg vascular stent tube blank; (c) Thermal-aided forming process of titanium dental abutment

References


Multiscale and multiphysics modeling techniques

Thanks to the rapid development of computational physics, applied mathematics, computer graphics and computer hardware, the ability of the CAD/CAE software in modeling practical engineering problems has been enhanced significantly. The CAD/CAE software is the key technology and strategic highland of modern industry. However, more and more practical physical procedures cannot be described with one physical equation under single scale, i.e., the multiscale and multi-physical nature has been revealed. For example, the black barrier effect of hypersonic vehicles involves fluid-thermal-electromagnetic coupling, while the integrated simulation of the IC from chip level to board level is a multiscale problem ranging from micrometer to centimeter. The response of the compound shielding materials of aircraft under lightening or HPM is a very challenging multiscale and multiphysics problem. If the conventional academic code in computational physics community or the commercial software is used, the simulations may fail due to the long CPU time or large memory requirement. Therefore, new techniques are needed to solve the above mentioned problems.

In this research, the discontinuous Galerkin time domain (DGTD) method was employed to simulate multiscale problems efficiently combining the techniques such as non-conformal mesh, hp refinement and implicit-explicit time integration. In multiscale simulation, if the conventional conformal grids are used, the calculation will be quite low-efficient or even fails due to the large quantity of unknowns. However, the non-conformal mesh, as illustrated in Fig 1 (a), allows the abrupt changes of sizes of elements across the interfaces, leading to a significant drop of degrees of freedom (DoFs). The advantage of non-conformal mesh is more obvious for 3D problems. In addition, the multiscale problems contain both the electrically large parts, such as background medium, perfectly matched layer (PML), large bulk of homogenous materials, and the electrically fine parts, such as small antennas, via holes in the integrated circuits. If the basis functions use the same interpolation order, it is difficult to achieve a balance between efficiency and accuracy. Therefore, hp refinement strategy was used in this research, i.e., high order hexahedrons (structured or unstructured) were used to mesh the electrically large parts to decrease DoFs, and low order tetrahedrons were used to mesh the electrically fine parts to catch the geometrical details in order to enhance the accuracy of the solution, as shown in Fig 1 (b). Another important parameter in time domain simulation is the simulation time interval ($\Delta t$), which determines the total CPU time of the

![Fig 1. (a)Non-conformal mesh. (b)hp refinement for nanoantenna simulation](image)
simulation. If conventional explicit time integration scheme which is limited by the CFL condition is used, the tiny mesh element from the mesh will lead to an extremely small $\Delta t$. Consequently, it will require a large number of time steps for a fixed observation window. In this work, the implicit-explicit hybrid time stepping method was employed, in which the explicit time stepping was just for the electrically large part while the implicit time stepping, free from the CFL condition, was used for the electrically small part. In this way, the total CPU time of simulation can be decreased at the expense of an acceptable increase in memory consumption. Finally, a multi-domain multi-solver DGTD method is obtained for solving the multiscale problems efficiently and accurately, as shown in Fig 2.

One of the most representative multiphysics problems is the electric-thermal coupling, such as the influence of the plasma sheath on the electromagnetic wave propagation and the influence of the Joule heat on the voltage network of the integrated circuits. For the electric-thermal coupling problem, this research proposed an approach which is a hybrid of high-order spectral element time domain (SETD) method and the subdomain level discontinuous Galerkin time domain (SL-DGTD) method. The high order SETD uses nodal basis functions for solving the thermal conducting process, and the geometrically second-order hexahedrons are used to accurately model the curved surfaces. Since the mass matrix is diagonal, it is more efficient than the electromagnetic solver which uses vector basis functions. The SL-DGTD method utilizes the domain decomposition scheme for cutting down the computation load. In addition, the implicit time stepping scheme is employed to minimize the temporal scale difference between the electrical and thermal process, thus enhancing the overall computational efficiency. This approach has been successfully applied to the simulation of the power net of the integrated circuits as illustrated in Fig 3.

In this research, efficient and accurate time-domain simulation approach for the multiscale and multiphysics analysis is proposed employing new technologies such as domain decomposition based on discontinuous Galerkin scheme, non-conformal mesh, hp refinement, implicit-explicit time stepping, high order basis function, etc., which provides theoretical basis and paves the way for the efficient simulation of multiscale and multiphysics problems in CAD/CAE software.

References
Ab initio/transition-state theory study of the reactions of \( \text{C}_5\text{H}_9 \) species of relevance to 1,3-pentadiene, part I: potential energy surfaces, thermochemistry, and high-pressure limiting rate constants

Despite the relatively small amount of unsaturated compounds in transportation fuels, they have significant influence on flame speed of the fuels. Moreover, 1,3-dienes are important intermediates in the pyrolysis and oxidation of higher-order hydrocarbons, and their combustion kinetics is important to the hierarchical development of kinetic mechanisms for hydrocarbon combustion. However, there have been few kinetic studies of dienes larger than \( \text{C}_4 \), while the presence of two double bonds in diene molecules increases the system’s chemical complexity. Based on previous studies of butadiene oxidation\[2, 3\], \( \textit{H} \) atom addition reactions were found to be very important in the accurate prediction of ignition delay time at high temperatures (>1000 K) and flame speed.

The \( \text{C}_5\text{H}_9 \) potential energy surfaces (PES) determined at CCSD(T)/\( \text{MP2}/\text{CBS}/\omega\text{B97XD/aug-cc-pVTZ} \) level of theory, illustrated in Fig 1, consist of 63 species and 88 transition states (TS), and can be divided into isomerization (in blue), \( \beta \)-scission (in red), ring-opening and ring-closing (both in green) reaction types. Because of the complexity of the \( \text{C}_5\text{H}_9 \) PESs, the complete \( \text{C}_5\text{H}_9 \) PESs are illustrated in two parts: (a) the formation of the 2,4-\( \text{C}_5\text{H}_9 \) radical (W1), 2,5-\( \text{C}_5\text{H}_9 \) radical (W2), and their subsequent reactions; (b) the formation of the 1,4-
C₅H₅ radical (W3), 1,3-C₅H₅ radical (W4), and their subsequent reactions. The enthalpies of formation at 0 K for all species involved have been calculated based on atomization approaches, using CBS-APNO, G3 and G4 composite methods. The temperature-dependent thermochemical properties: enthalpies, entropies and heat capacities have been obtained via calls to the ThermP code, based on the partition functions computed using MESS code, and were found to be in good agreement with the values in ATcT, NIST and Burcat databases. For simplicity and clarity, the PESs of each C₅H₅ radical and its subsequent reactions are presented separately, shown in Fig 2. For each species, the related reactions are analyzed in terms of heat of reaction, barrier height, TS structure, and reaction class.

Depending on the temperature and/or pressure, the resonantly stabilized 2,4-C₅H₅ radical is the dominant product produced from the addition of H atoms to 1,3-pentadiene, and it is likely to be among the dominant products of abstraction reactions from 2-pentene by important radical species including H and O atoms, OH and HO₂ radicals, etc. Its chemically activated and thermal unimolecular reactions are therefore of importance in numerous scenarios of relevance to alkene and diene high temperature combustion chemistry.
As shown in Fig 2 (a), the reaction enthalpies and barrier heights follow some clear trends. The endothermicity increases as the product radicals change from allylic, to primary, and then to vinylic, while the reaction barriers follow similar trends. According to the high-pressure limiting (HPL) rate constants for the reaction pathways of 2,4-\(\text{C}_5\text{H}_9\) radical, isomerization to 1,3-\(\text{C}_5\text{H}_9\) and back dissociation to 1,3-pentadiene + H are the most important reaction channels.

For the 2,5-\(\text{C}_5\text{H}_9\) radical shown in Fig 2 (b), isomerization via a six-membered ring to form 1,3-\(\text{C}_5\text{H}_9\) radical dominates at temperatures below 1800 K. The dominant product for the 1,3-\(\text{C}_5\text{H}_9\) radical depicted in Fig 2 (c) is 1,3-butadiene.
Fig 3. Evans-Polanyi relationships for (a) ḃH atom additions to linear dienes and alkynes, (b) exo- and endo-cycloaddition reactions of ĊH₉ radicals, (c) isomerization reactions of cyclic ĊH₉ radicals, (d) C-C and C-H bond breaking reactions of cyclic ĊH₉ radicals, (e) 1,2- and 1,5-H shift isomerization reactions of linear ĊH₉ radicals and (f) C-C and C-H bond breaking reactions of linear ĊH₉ radicals.

+ ċH₃ via C–C β-scission, while the dominant channel for the 1,4-ĊH₉ radical shown in Fig 2 (d) is a fast homoallylic rearrangement reaction to form 3-methyl-1-buten-4-yl (W14) via 1-methyldienecyclopropylmethyl (W13).

The Evans-Polanyi relationships for the reactions of ḃH atoms with acetylene, allene, propyne, butyne and butadiene isomers, and pentyne and pentadiene isomers (this study) are compared in Fig 3 (a). The C₃ – C₅ dienes are observed to have different correlations of barrier heights and reaction enthalpies, and can be divided into three groups, namely, (1) ḃH atom addition to linear 1,3-dienes; (2) ḃH atom additions to linear 1,2- and 2,3-dienes forming allylic alkenyl radicals; (3) ḃH atom additions to linear 1,2- and 2,3-dienes forming vinylic alkenyl radicals, and ḃH atom additions to 1,4-dienes and alkynes. These Evans-Polanyi correlations might be useful when only ΔH₂⁰ values are available for reactions of interest in the literature. Moreover, for the three reaction classes (H-shift isomerization, cyclo-addition, and β-scission reactions) involved, the Evans-Polanyi correlations have been developed, as illustrated in figures 3 (b) – (f), and can be used to estimate the energy barrier where literature data are unavailable.

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References
Strong bioinspired HPA-rGO nanocomposite films via interfacial interactions for flexible supercapacitors

Flexible electronics with portable, wearable, bendable, and foldable characteristics are burgeoning technologies for widespread applications in sensors, healthcare, portable electronics, intelligent devices, and micro-robotics, especially for aeronautics and astronautics, due to their flexibility and being light in weight. Hence, well-matched energy storage devices with flexibility that are light in weight and have excellent mechanical properties, high capacity, long cycle life, and remarkable energy density are urgently needed. Recently, intensive research efforts have been directed towards developing flexible supercapacitors (such as lightweight thin films) to adapt for different flexible electronics applications.

As candidates for energy storage devices, flexible supercapacitors are a potential alternative to traditional batteries because of their outstanding mechanical properties, higher energy density, fast charge-discharge capacity, long cycle life, and superior safety. However, developing flexible supercapacitors based on electrodes with robust mechanical properties and high capacitance remains a great challenge.

Herein, inspired by the interfacial interaction design of natural nacre, we described an effective and novel strategy to assemble halloysite-polyaniline-graphene oxide (HPA-GO) nanocomposite films via synergistic interfacial interactions of π-π conjugated bonds, hydrogen bonding, and electrostatic interaction (Fig 1). The achieved HPA-rGO nanocomposite films show excellent tensile strength with 351.9 MPa, toughness with 8.5 MJ m⁻³, and high electrical conductivity with 397.0 S cm⁻¹.

The synergistic toughening mechanism is illustrated in Fig 2. The conductive PANI molecules grafted on the HA with electrostatic interaction are crosslinking with the rGO nanosheets through π-π conjugated bonds and hydrogen bonding. When the loading starts, the rGO nanosheets gradually slide over each other while the soft coiled PANI chains begin to be stretched along the sliding direction. With increased loading, the chains of PANI are further stretched until the fracture occurs along the direction of sliding. Under this process, the major dissipation of energy is mainly caused by the rupture of π-π conjugated bonds and hydrogen bonding. Finally, the rGO nanosheets are pulled out from the laminated structure, resulting in curving edges of rGO nanosheets.

Moreover, the stability of the dynamic electrochemistry properties for the flexible all-solid-state supercapacitors (ASSSs) was also investigated by changing the states of the ASSSs (Fig 3). CV curves of ASSSs while flat, being stretched, and being bent remained almost stable even after 5000 cycles of bending, which implies the remarkable flexibility of the supercapacitor. The specific capacitance
Fig 2. a) Typical stress-strain curves of the pure GO film (curve 1), rGO film (curve 2), HPA-GO-II (curve 3), HPA-rGO-II (curve 4), and PANI-rGO-II (curve 5). The results show that when the HPA nanocomposites are introduced into the layers of GO nanosheets, the tensile strength has enhanced compared to pure GO and rGO films, which is attributed to the synergistic interfacial interactions between HPA and rGO nanosheets. b) The tensile strength of HPA-GO and HPA-rGO nanocomposite films with different weight ratios of HPA. The results present the optimal weight ratio of HPA is 14.7 wt%. c) Comparison graph of tensile strength and strain of HPA-rGO-II nanocomposite film with other graphene-based electrodes for the flexible supercapacitors, which shows the tensile strength of HPA-rGO-II nanocomposite film is much higher than all reported graphene-based electrodes by far. d) Illustration of the fracture process of bioinspired HPA-rGO-II nanocomposite film due to the synergistic interfacial interactions of bioinspired nanocomposite film. e) The cross-section view and f) side view of fracture morphology of HPA-rGO-II nanocomposite film. The fracture morphology with the obvious curve of edges shows the dissipation of load is due to the synergistic interfacial interactions between HPA and rGO nanosheets. g) The electrical conductivity of pure rGO film and HPA-rGO nanocomposite films show that the HPA-rGO-II reaches the maximum value at the HPA content of 14.7 wt%.

Fig 3. a) Schematic diagram illustrating the architecture; b) CV curves at scan rates from 10 to 100 mV s$^{-1}$ of the flexible supercapacitor; c) Specific capacitance at different current densities from 0.1 to 1.6 A g$^{-1}$ of the all-solid-state supercapacitors for HPA-rGO-II nanocomposite film; d) CV curves at 10 mV s$^{-1}$ of the flexible supercapacitor; e) Capacitance retention; f) The Ragone plot.

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Developing new high energy and power density electrode materials to substitute low capacity graphite in lithium-ion batteries (LIBs) is imminent owing to the soaring tendency of electric vehicles and ever lighter portable electronic devices. As a rocking-chair battery, Li ions shuttle between anode and cathode of LIBs through insertion and extraction, inevitably causing large volume expansion and shrink induced pulverization and aggregation of solid electrode material. In order to conquer the volume breath effect, hollow electrode material has been verified to be able to effectively alleviate the volume change. However, an awkward contradiction is that the tap density of hollow materials is normally lower than the solid counterparts due to the excessive inner space of the routine hollow structures. How to balance the high volumetric energy density of solid structure and high cycling stability of hollow structure has become an obstacle to high performance LIBs. In addition, the design of transition metal oxide and carbon composite hollow structure has proved to be an effective strategy to improve the battery rate performance.

In this work, we demonstrated a facile and efficient method to synthesize wire-in-double-wall-tube Sn/SnO$_2$@C composite hollow nanofibers. First, wire-in-tube SnO$_2$ nanofibers were obtained by precisely controlling the heating rate.

![Fig 1. The fabrication scheme of multi-wall Sn/SnO$_2$@C hollow nanofibers](image)
Then, the polypyrrole was in-situ coated on the surfaces of the SnO$_2$ nanofibers, and then the wire-in-double-wall-tube Sn/SnO$_2$@C composite nanofibers were obtained by in-situ calcination and reduction process. The double-tube layers reserve sufficient but not excessive spaces between core and shells, effectively alleviating volume expansion and ensuring favorable transport kinetics for both Li ion and electron during charging/discharging process. The cooperation of multi-structure and composition optimization contributes to the excellent rate capability (812.1 mAh g$^{-1}$ at 1 A·g$^{-1}$ and 566.5 mAh g$^{-1}$ at 5 A·g$^{-1}$) and remarkable cycling performance (986.3 mAh g$^{-1}$ at a current of 1 A·g$^{-1}$ and 508.2 mAh g$^{-1}$ at 5 A·g$^{-1}$ after 2000 cycles) as the anode materials of LIBs, which is greatly superior to current electrode materials.

This work proposed a highly designable and reliable inorganic and polymeric chemical combination strategy in preparing hollow electrode materials with controllable multiscale inner structures and chemical composition, which rationally resolved the high capacity and long cycle life conflict of LIBs. This work paves a promising way to developing high-performance anode materials for next-generation LIBs as well as many other electrochemical active materials, which can be very attractive to not only inorganic, macromolecule and electrochemistry scientists in the chemistry domain, but also researchers in energy, materials science, and nanotechnology. This study has been published in Angew. Chem. Int. Ed. (DOI:10.1002/anie.201913170). The first author is Songwei Gao, a Master’s student of Beihang.

Fig 2. Structure and composition of SnO$_2$ and multi-wall Sn/SnO$_2$@C hollow nanofibers
Fig 3. Electrochemical lithium storage properties of the multi-wall Sn/SnO$_2$@C hollow nanofibers

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Cheers and roses from undergrads for Yale’s Nobel laureate

Edited from the original article by Mike Cummings

William Nordhaus, Sterling Professor of Economics, entered his classroom at Dunham Laboratory Monday morning to a burst of uproarious applause.

Hours earlier, Nordhaus learned that he had been awarded the 2018 Nobel Prize in Economic Sciences. He would not allow the exciting news to interfere with his commitment to his undergraduates in intermediate macroeconomics.

“Congratulations Prof. Nordhaus” was written in big letters on the blackboard in classroom 220. A student handed the newly minted Nobel laureate a bouquet of flowers. Others took pictures with their smart phones.

“Special rule for today: You can have your cell phones,” he said to laughter once the cheers had subsided. “As Yale students and faculty you learn how to deal with distractions. Don’t let anyone distract you from the work at hand, which is economic growth. Maybe I’ll say more later, but were you clapping about quiz two?”

Nordhaus is a pioneer in the economic analysis of climate change. He received the Nobel for “integrating climate change into long-run macroeconomic analysis,” according to the prize citation. He shared the honor with Paul Romer, professor of economics at New York University’s Leonard N. Stern School of Business.

The students said they were proud of their teacher.

“It’s very exciting and so tangible that we have access to very distinguished faculty,” said Fausto Hernandez, a sophomore. “His teaching style every day is so humble and so approachable — in fact, uniquely approachable. It really speaks to his ability as an educator and researcher. The way in which he understands very complex concepts and explains them so simply is wonderful. Every time we come to class my understanding of economics improves so much.”

Amanda Zhang, a sophomore, said it is exciting to have the opportunity to learn from a world-renowned economist and added that Nordhaus has a gift for teaching.

“I was nervous about taking this class because I didn’t consider myself someone who had a very strong background in economics, but he has been doing a really great job of explaining the basics and getting people interested in the material,” Zhang said.

Nordhaus’ research has focused on economic growth and natural resources, the economics of climate change, and resource constraints on economic growth. Since the 1970s, he has developed economic approaches to global warming, including the construction of integrated economic and scientific models (the DICE and RICE models) to determine the efficient path for coping with climate change. These models are widely used today in research on studies of climate-change economics and policies. He has also studied wage and price behavior, health economics, augmented national accounting, the political business cycle, productivity, and the “new economy.”

If you would like to read more about William Nordhaus and his research, please visit https://news.yale.edu/2018/10/08/yales-william-nordhaus-wins-2018-nobel-prize-economic-sciences

(Photo credit: Mara Lavitt)
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ABOUT BEIHANG UNIVERSITY

Founded in 1952, Beihang University (BUAA) is the first higher education institution featuring aeronautics and astronautics established after the founding of the People’s Republic of China in 1949. As one of the top research universities in China, Beihang University is under the supervision of the Ministry of Industry and Information Technology. Ever since its founding, Beihang has been the university given priority for development, one of the first 16 National Key Universities, and one of the 22 universities to establish graduate schools since degree system was reintroduced in the 1980s. It was one of the first universities to be funded by China’s government initiated “Project 211” and became a member of “Project 985” in 2001. In 2013, Beihang University became one of the first National Collaborative Innovation Centers in “Program 2011”. In 2017, Beihang was chosen as “Class A University” in the “Double First-Class” plan, which includes major support from the Chinese Ministry of Education and other government departments to build a world-class university with first-class subject areas.

Beihang University is committed to providing high-level education and research to better foster innovation and creativity in order to cultivate leaders who contribute to the development of the nation and the world. Engineering, material sciences, physics, computer science, chemistry, and social sciences (general) rank top 1% in the Essential Science Indicator database, with engineering and material sciences ranking top 1‰, which marks its competitiveness in building world-class subject areas. There are 8 degree programs for priority development (tied for seventh in the nation), 28 fields of study (second level disciplines) for priority development in the nation, 10 programs of study for priority development in Beijing, and 10 programs of study for priority development related to national defense. According to results of the fourth round of assessment of programs of study nationwide released in December 2017, Beihang University has 14 programs of study listed in Class A. Aerospace science and technology, instrument science and technology, materials science and engineering, and software engineering are listed as A+.

A large number of renowned scientists and professors as well as many young and promising scholars with profound attainment are contributing their wisdom and intelligence to the development of the University. Among them are 23 academicians of the Chinese Academy of Sciences or the Chinese Academy of Engineering, 59 Changjiang Professors, 59 recipients of “National Science Fund for Distinguished Young Scholars”, and 5 awardees of National Excellence in Teaching. Significant contributions have been made by Beihang University faculty members. A number of outstanding faculty members have been awarded First Prizes of national level science and technology awards or become prominent scientists and chief engineers.

The innovative capacity that meets the national strategic needs is a high priority for Beihang University, which enhances basic, forward-looking, and strategic high-tech research, gathers together key elements to innovation to break technology bottleneck, and, at the intersection of industry, academia, research and application, builds top innovation platforms and research groups. The total amount of scientific research activities is increasing. The per capita amounts of research expenditure rank number 1 among higher education institutions in the country. It has 9 State Key Laboratories, 4 National Engineering Research Centers, over 70 provincial or ministerial-level key laboratories, 7 Innovative Research Groups of the Natural Science Foundation of China, 12 Innovative Research Groups of the Ministry of Education, and 6 Innovative Research Groups of National Defense Science and Technology. Since the “10th five-year plan” period, Beihang has been awarded more than 60 prizes from the three major science and technology awards at national level, including 14 national First Prizes, and 4 Second Prizes of National Natural Science Award in 14 years, which sets the record for a university receiving the highest level of national science and technology awards in consecutive years and affirms the success of the “Beihang
model” for scientific innovation. Beihang remains committed to strengthening basic research and enhancing innovative capacity. Breakthroughs have been made in both the quality and quantity of papers published in top international journals including Science and Nature.

“We have started the journey toward the sky and clouds high and far, our world lit up with achievements like the bright stars”. Standing at a new historic starting point, Beihang University will further broaden its horizon in planning for the future. “Under the guidance of Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era, we shall enhance our ‘Four Consciousnesses’ – maintaining political integrity, thinking in big-picture terms, following the leadership core, and keeping in alignment, and we shall further strengthen our confidence with ‘Four Matters of Confidence’ – confidence in socialist path, theory, system, and culture, safeguarding Xi Jinping’s core role, the Central Committee’s authority, the Party’s unity and centralized, unified leadership.” Efforts to strengthen Party leadership over education are the fundamental guarantee for the development of education, which provides a strong political guarantee for the University’s development. The University upholds the core values that promote and shape its mission of serving the country. It’s imperative to stick to the path of socialist education with Chinese characteristics, and Beihang shall adhere to the socialist direction so as to become a world-class university with world-class subject areas, comprehensively fostering the students’ all-round moral, intellectual, physical and aesthetic grounding with a hard-working spirit and nurturing capable young people well-prepared to join the socialist cause. The University will quicken its pace in building a world-class university rooted in the homeland of China, with Beihang Dream a major force in realizing the Chinese Dream of the great rejuvenation of the Chinese nation.

(with data up to October 2019)

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