Stable slippery liquid-infused anti-wetting surface at high temperatures†

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Recently developed slippery liquid-infused surfaces (LIS) offer a new approach to construct anti-wetting surfaces due to their excellent repellence of various liquids. However, previous studies about LIS are mainly performed at room temperature or low temperature and the LIS with stable anti-wetting at high temperatures are rare. Here we report a facile method to prepare LIS with high-temperature resistance. We directly employed chemically etched stainless steel (CESS) as the substrate structure, which can be applicable to objects regardless of their shapes and sizes. By choosing silicone oil to infuse the silanized CESS, a slippery surface with a very low sliding angle (ca. 2°) was formed, and the successful preparation can be achieved even when the silanized CESS was annealed at a temperature of 600 °C. The as-prepared LIS showed excellent anti-wetting for both room-temperature water and hot water at high temperatures. On the basis of stable LIS with high-temperature resistance, we investigated the influence of temperature on the droplet movement on LIS, and found that there were three movement states for both the sliding and impacting of water droplets on LIS with increasing temperature. We envision that our proposed approach can broaden the applications of LIS in engines, medical instruments, and daily life.

1. Introduction

Surfaces with the capacity to repel water at high temperature have extensive application potential ranging from fundamental research to practical applications, especially for those used under harsh high-temperature conditions including electro-surgical instruments, engines, hot-water pipelines and so forth. 1–4 Superhydrophobic surfaces, well-known as the lotus effect, 5 have been considered to be the ideal choice due to their excellent repellence for water. By combining surface structures with low surface tension materials, superhydrophobic surfaces can hold air in place to form a stable solid/air composite surface, on which the water droplet is in the Cassie–Baxter state, resulting in a low contact angle hysteresis. 6–7 But as most superhydrophobic surfaces repelling water in previous studies are confined to room temperature, 8 repelling water on high-temperature surfaces and repelling hot water have become bottleneck problems. Liu et al. reported that superhydrophobic surfaces could lose their repellence to hot water owing to the transition of the wetting state from the Cassie–Baxter state to the Wenzel state, 9 leading to a reduced repellency and even pinning. On extremely hot superhydrophobic surfaces with temperature above the boiling point (approximately 150 °C), small water droplets could bounce off the surface due to the Leidenfrost effect, 9 induced by a vapor layer from the water evaporation. While when the temperature is lower than the Leidenfrost temperature or when an amount of water is splashed on the surface, the heat transfer may be insufficient to generate a stable vapor layer, in which the superhydrophobic surface could also be wetted.

Recently, novel slippery liquid-infused surfaces (LIS), inspired by the pitcher plant Nepenthes, offer a new approach to construct anti-wetting surfaces. 10–12 Similar to the concept of designing superhydrophobic surfaces, slippery surfaces are constructed by combining suitable surface structures with the infused liquid, which is held in place by the structures just like the locked air in superhydrophobic surfaces. 11,13 To avoid the wetting of the repelled liquid on the surface structure, the surface must have preferential affinity for the infused liquid. The infused-liquid and the surface structures can form a stable solid/liquid composite surface which results in a very low contact angle hysteresis (ca. 1°) for the repellent liquid immiscible with the infused-liquid, thus possessing remarkable anti-wetting capacity. 11,13 Previous studies have demonstrated that LIS have stable slippery anti-wetting capacity for water under high relative humidity, 10,16,17 high pressure, 11 water flow, 18–20 physical damage, 21 and also for the attachment with ice and bacteria. 16,22–24 However, there are very few studies involving the
slippery performance of LIS under high temperatures.\textsuperscript{1,25-26} Zhang et al. demonstrated the rapid evaporation of the infused liquid of the LIS and its easy-sliding failure at slightly high temperatures.\textsuperscript{25} Daniel et al. reported the omniphobicity of LIS based on a Teflon membrane,\textsuperscript{1} while static and dynamic anti-wetting behavior under different high temperatures still lack studies. Although some materials,\textsuperscript{11,27-34} including Teflon membranes,\textsuperscript{11,23,25} porous polyelectrolyte multilayers,\textsuperscript{25} nanoporous cellulose lauroyl esters\textsuperscript{28} and silicon nanofoils\textsuperscript{29} have been chosen as the structure layer to prepare LIS, very few of them have been reported with high-temperature resistance. For example, a Teflon membrane will degrade and release poisonous particles and gas when the temperature is above 350 °C.\textsuperscript{3}

In this paper, we propose a facile method to prepare the LIS with high-temperature resistance based on the infusion of silicone oil into the silanized chemical etched stainless steel (CESS) surface. This surface structure constructing method, directly etching the substrate, can be applied to objects regardless of their shapes. Octadecyltrichlorosilane (OTS), with excellent chemical, mechanical, and thermal stability,\textsuperscript{36-38} has been chosen to silanize CESS. The annealing experiments demonstrated that the silane-functionalized surface could withstand high temperatures of up to 600 °C. On the basis of this stable high-temperature resistance, the static sliding and dynamic impacting of water droplets on the as-prepared LIS at different high temperatures were investigated. Besides, the LIS showed anti-wetting for hot water under both room temperature and high temperature, and also demonstrated remarkable high-temperature stability and resistance to physical scratches.

2. Experimental section

2.1 Materials

A plate of stainless steel (316 SS-plate) was commercially obtained from Hongtu Corporation (Guangzhou, China). \(\text{H}_3\text{PO}_4\) (phosphoric acid), HCl (hydrochloric acid), and FeCl\(_3\) (ferric chloride) in chemical etching solution, obtained from Tianjin Chemical Corporation (Tianjin, China), were analytically pure and used as received. Silicone oils, with different kinematic viscosity, were used as the infused liquid and were purchased from Beijing Chemical Works (Beijing, China) (details see Table S1, ESI\(^*\)). Octadecyltrichlorosilane (OTS), purchased from Huaxia Reagent (Chengdu, China), was applied as the silane to functionalize the etched surface to promote the spreading and impregnation of the silicone oil. Anhydrous toluene, used as solvent in OTS solution, was obtained from Beijing Chemical Works (Beijing, China), was analytically pure and used as received.

2.2 Preparation of slippery liquid-infused surface on stainless steel

The SS-plate was first thoroughly washed by ultrasonic cleaning in the order of deionized water, \(n\)-hexane, acetone, and ethanol for 10 min, respectively, followed by vacuum drying for 30 min. Chemical etching, in a beaker with approximately 500 mL of etching solution (composition: \(\text{FeCl}_3\), 400 g L\(^{-1}\), phosphoric acid 20 g L\(^{-1}\), hydrochloric acid 100 g L\(^{-1}\)), was then conducted to produce the surface structure on the SS-plate. After chemical etching for 10 min, the SS-plate was taken out and washed with deionized water followed by vacuum drying at 100 °C for 30 min. Then oxygen plasma surface modification of the SS-plate was conducted using RF plasma (PBC, Schwarz, China) at an RF power of 100 W for 10 min, a system pressure of 100 µbar and a flow rate of 20 scm. The oxygen treatment produced the hydroxyl groups required to facilitate the subsequent OTS self-assembly on the surface, in view of the grafting process: the trichloro groups of OTS are hydrolyzed by surface bound water to yield highly reactive silanols and then the formed silanols react with surface hydroxyl groups as well as with neighbouring molecules to form a highly stable cross-linked network on the surface.\textsuperscript{39} For OTS self-assembly, the oxygen plasma treated rough SS-plate was immersed in 1 mM OTS solution in anhydrous toluene at room temperature for 4 h. After self-assembly, the stainless steel was sequentially ultrasonic-cleaned in anhydrous toluene to remove the unreacted monomer OTS and dried under a nitrogen atmosphere. Approximately 20 µL cm\(^{-2}\) silicone oil was dropped onto the functionalized CESS to create LIS, as shown in Fig. 1a. The liquid could completely wet the surface via capillary force from the structures. Prior to use, the liquid-infused substrate was placed vertically for 5 h to drain off the excess liquid.

2.3 High-temperature resistance characterization of the OTS coated stainless steel

To investigate the high-temperature resistance of the OTS coated CESS and the effect of the heat treatment on the LIS construction, the OTS coated surfaces were annealed on a temperature-controlled hotplate for temperatures below 400 °C (the highest temperature for hotplate) and in an annealing oven for temperatures above 400 °C with treatment time of 30 min. After heat treatment, the water contact angle (CA) on the treated surfaces was measured to evaluate the surface chemistry property change. The silicone oil was also added onto the treated surfaces to investigate the effect of heat treatment on the LIS construction, evaluated by measuring the critical sliding angle (SA).

2.4 Water droplet sliding and impacting on the LIS with different temperatures

Water droplet sliding and impacting on the high-temperature LIS were conducted to analyze the effect of high temperature on the as-prepared LIS (surface size: 3 cm \(\times\) 3 cm). For droplet sliding experiments, the LIS were placed on the temperature-controlled hotplate with a tilt angle of 5° and a water droplet (10 µL) was slowly deposited onto the surface. The movement of the droplet was monitored by a high-speed camera (I-speed LT, Olympus, Japan). For drop impacting experiments, an injector was fixed over the hotplate with a tilt angle of 5° and the water droplet (10 µL) was slowly pushed out. The droplet impacting
process on the high-temperature LIS surface was monitored by the high-speed camera.

2.5 Stability of the slippery stainless steel with different viscosities of silicone oil

The stability of the slippery surface with different viscosities of silicone oil was investigated by measuring the critical SA after cycles of heating/cooling treatment. Specifically, the surface was first heated on the hotplate at a temperature of 250 °C for 10 min, and then the surface was completely cooled by immersing the substrate into room-temperature water for 2 min. After the heating/cooling treatment, the critical SA was measured.

2.6 Morphology, surface chemistry and wettability characterization

Surface morphologies of the stainless steel surfaces were characterized using a scanning electron microscope (SEM, JSM-6010, JEOL, Japan). An atomic force microscope (AFM, Nanoscope, Veeco, America) was employed to scan the three-dimensional surface morphology. ATR-FTIR spectra measurement on the CESS before and after OTS self-assembly were recorded using Fourier transform infrared spectroscopy (FTIR, UV-3600, Shimadzu, Japan) with an attenuated total reflectance (ATR) accessory. X-ray photoelectron spectroscopy (XPS) analyses were performed on an AXIS Ultra spectrometer (Kratos, England) with an Al Kα source. All binding energies were referenced to C1s adventitiously at 284.8 eV with an energy resolution of 0.48 eV. An optical contact angle measuring system (SL200B, Solon, China) was applied to measure the CA and the SA of the water droplets (4 μL). The average angle value was obtained by measuring at five different positions on the same sample.

3. Results and discussion

The slippery LIS are constructed by combining the surface structure and the infused liquid. The surface structure provides the place to hold the infused liquid and forms a solid/liquid composite surface to repel the other liquids. To prohibit the repelling liquids from wetting the substrate structure, the infused liquid must have a preferential affinity for the substrate structure compared with the repelled liquids. Generally, surface functionalization should be first performed to construct a molecular layer or a coating layer that can be preferentially wetted by the infused liquid. So, to prepare LIS with high-temperature resistance, both the substrate structure and the surface functionalization layer should have resistance for high temperatures.

Stainless steel, with its excellent high-temperature resistance, is one of the most widely used metals in electrosurgical instruments, mechanical engines, and daily life. Herein, we develop SS-based LIS by directly using the SS as the substrate surface. Chemical etching, a simple method to roughen the metal surface, was employed to fabricate the surface structure of the SS surface. Fig. 1b shows the surface structure after the SS-plate was chemically etched for 10 min. As seen in the SEM image, there are plenty of irregular bump and pit structures existing on the surface. The enlarged image (Fig. 1c) exhibits that these structures are at a scale ranging from sub-micrometers up to ~5 μm, which is suitable to be used as the holding structures. We choose the silicone oil as the infused

Fig. 1  (a) Schematic of the preparation process of SS-based LIS. SEM images of etched stainless steel (b) before and (e) after OTS self-assembly. (c) and (f) are the enlarged SEM images marked in (b) and (e), respectively. AFM images of etched stainless steel (d) before and (g) after OTS self-assembly. (i) ATR-FTIR spectra of etched stainless steel before (dark line) and after (red line) OTS self-assembly.
liquid not only because of its low surface tension but also because of its excellent high-temperature resistance and good biocompatibility,\textsuperscript{41,42} while the substrate surface must be functionalized with silane to match the chemical properties of the silicone oil. An OTS self-assembled monolayer with excellent chemical, mechanical, and thermal stability on the hydroxylated surfaces was chosen to silanize the substrate surface. Fig. 1e shows the surface morphology of the OTS coated CESS, which is significantly rougher than CESS. In fact, the hydrolysis process of OTS molecules on the substrate surface released hydrochloric acid and could further etch the CESS.\textsuperscript{39,43}

Compared with CESS (Fig. 1c), the structures on the OTS coated CESS were more sharp (Fig. 1f). Fig. 1d and g show the AFM images of CESS and OTS coated CESS, respectively. The roughness values ($R_a$) of the substrate surface before and after OTS self-assembly were 228 nm and 314 nm, respectively, in accordance with the above analysis. ATR-FTIR spectra were also measured to characterize the chemistry property changes before and after OTS self-assembly (Fig. 1i). The peaks of methylene symmetric (2849 cm$^{-1}$) and asymmetric stretching (2918 cm$^{-1}$) were observed on the OTS coated CESS (red line), demonstrating the successful construction of an OTS self-assembled monolayer on the CESS.\textsuperscript{44} To further confirm the presence of silicon Si–O after OTS self-assembly, XPS analyses were performed (Table S2, ESI†). Significant increases in carbon and silicon appear on the OTS coated CESS. From the spectra, we note that the main C1s peaks of oxygen transfer from 530.50 eV (metal oxides) and 531.74 eV (metal carbonates) to 532.05 eV (organic C–O) and 532.92 eV (Si–O), and the main C1s peaks of silicon transfer from 102.29 eV (aluminosilicate) to 103.25 eV (Si–O) (for details see Fig. S1, ESI†). On the basis of the XPS analyses, the presence of an OTS monolayer on the OTS coated CESS can be further concluded.

The OTS self-assembled monolayer, having a preferential affinity for silicone oil compared with water, enables the substrate surface to hold the infused silicone oil in place, resulting in a stable solid/liquid composite surface, which greatly impacts the wettability of the surface. As shown in Fig. 2a and c, the static water CA on the OTS coated CESS was 120.4°, while it decreased to 87.8° after the silicone oil was added onto the surface. As for the SA, the water droplet was found to be firmly pinned on the OTS coated CESS even when the substrate surface was placed vertically. However, the water droplet could easily slide on the SS-based LIS with a very low tilt angle of ~2°, as shown in the time-lapse images in Fig. 2d. During our experiments, we noted that the sliding properties of the water droplet on as-prepared LIS greatly depended on the kinematic viscosity of the silicone oil. The water droplet had the largest sliding speed of ~0.72 mm s$^{-1}$ with a kinematic viscosity of 50 cSt and decreased with increasing kinematic viscosity, as shown in Fig. 2e. An evident decrease was found when the kinematic viscosity was increased to 500 cSt, and the water droplet was nearly pinned on the LIS with a very small sliding speed of ~0.09 mm s$^{-1}$. According to a previous study,\textsuperscript{19} the water droplet possesses a floating state on the completely wetted substrate surface by the infused liquid, and it is cloaked by the infused liquid. The increase in viscosity of the infused liquid increases the friction force and makes the liquid layer difficult to deform,\textsuperscript{44} resulting in a decrease in sliding speed. The results also give a method to tune the water droplet sliding, that is, by choosing the oil viscosity.

For LIS, the surface functionalization layer plays a vital role and avoids the repelled liquid droplet sinking to contact the substrate surface. We evaluated the high-temperature resistance of the surface functionalization layer by measuring the water CA after heat treatment of the substrate for 30 min, as shown in Fig. 3a. The CA on the OTS coated CESS without heat treatment is ~120°, and slowly decreased to ~103° with the increase of the heat treatment temperature up to 200 °C. At the heat treatment temperature of 250 °C, the CA rapidly decreased to ~81°, and then slowly decreased to ~41° at temperatures of 500 °C and 600 °C, which is near the contact angle of water (~39°) on the CESS (the dotted line in Fig. 3a). The rapid CA change above 250 °C indicated that the OTS self-assembled monolayer began to degrade, which was in good agreement with a previous study.\textsuperscript{37} In fact, the hydrophobicity of the surface is mainly determined by the C–H band, which decreases along with the degradation of the monolayer, resulting in the decrease in CA. The C–H band could completely be desorbed when the temperature was increased to 600 °C,\textsuperscript{37} while the Si–O–Si of the monolayer is still intact even after being heated at 600 °C and keeps the surface chemistry property to match the silicone oil with plenty of Si–O–Si bands. The subsequent critical SA measurement (Fig. 3b) on the LIS, prepared on the high-temperature treated substrate, demonstrated successful
When the temperature increased, the evaporation of the oil accelerated and tended to form a vapor layer over the oil. Meanwhile, the heat transfer from the oil to the water induced the temperature rising, which also produced water vapor between the oil and the water droplet. These vapors gradually formed a Leidenfrost vapor layer, when the surface temperature was increased, to prohibit the droplet from wetting the surface. Due to the slower evaporation rate and heat transfer for oil with higher viscosity, the movement transition is dependent on oil viscosity. This movement change also greatly influenced the movement speed on the surface, as shown in Fig. 4d, and the speed in both the rolling + sliding state and the rolling state is approximately two orders of magnitude larger than that on the sliding state. Although the movement state changed with increasing the surface temperature, the LIS kept the excellent anti-wetting in all the states.

Reliable slippery performance against dynamic droplets is also needed for LIS, especially facing droplet impact at high temperatures. According to a previous study, no rebound or partial rebound happened on the LIS for a water droplet impact. To investigate the effects of surface temperature and the viscosity of oil on the droplet retraction after impacting, we set the droplet-impacting condition as: water droplet (10 \(\mu\)L) slowly pushed out from an injector which was kept 50 mm higher than the hotplate (Weber number is approximately 36), in which no rebounding happened on the LIS at room temperature (25 °C). Fig. 5a shows images of the first retraction after droplet impacting (left image) and the subsequent movement after the first retraction on the LIS (right image) for the LIS with three types of viscosity at the temperatures from 25 °C to 300 °C (see ESI Video 2† for the typical droplet impact movement). We found that there were also three kinds of movement state after the droplet impact with increasing surface temperature: no rebounding to sliding (no rebounding after first impacting and then sliding), rebounding to sliding (rebounding after first impacting and then sliding), and rebounding (rebounding after first impact and then bouncing). The movement transition temperature was also influenced by the oil viscosity, and the movement map is illustrated in Fig. 5b. For viscosity of 50 cSt and 100 cSt, the transition temperatures (that is, the rebounding to sliding state) ranging from 100 °C to 200 °C and ranging from 150 °C to 250 °C, respectively. However, just two kinds of movement state (no rebounding to sliding and rebounding to bouncing) happened for a viscosity of 350 cSt.

The rebounding movement should be ascribed to the Leidenfrost effect. Here, the rebounding temperature was much smaller than the Leidenfrost temperature on the stainless steel (~280–310 °C). As foregoing analysis, these were two vapor sources: the silicone oil and the water droplet. The vapor from the silicone oil facilitated a vapor layer to form the Leidenfrost effect faster, that is, decreasing the transition temperature, while the evaporation of silicone oil greatly depended on the kinematic viscosity, thus the initial rebounding temperature increased with increasing viscosity. At the transition temperatures, the sliding, where the droplet became boiling, after the
The first retraction might result from an insufficient vapor layer to completely repel the droplet.\textsuperscript{48} The elevated temperature changed the droplet movement from sliding to rolling or bouncing, which further facilitated the droplet shedding. However, the elevated temperature also accelerated the evaporation of the infused oil and might induce the failure of the anti-wetting after a long-time heating. The evaporation of the silicone oil is the main reason to induce the failure of slippery property. We investigated the high-temperature durability of the as-prepared LIS by heating the

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**Fig. 4** Water droplet movement process when it was deposited on the LIS with a silicone oil kinematic viscosity of 100 cSt at the temperature of (a) 50 °C, (b) 200 °C, and (c) 300 °C. The substrate has a tilt angle of ~5°. (d) Water droplet movement speed on the LIS speed as a function of surface temperature with different kinematic viscosity.

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**Fig. 5** (a) Captured images of water droplet impacting movement on tilted LIS (≈5°) with different kinematic viscosities at different temperatures. For a water droplet impacting on specific a LIS, the left image represented the first retraction after initial droplet impacting (marked by the green arrows), and the right image represented the subsequent movement state after the first retraction (marked by the blue arrows). Scale bar: 1 cm. (b) Movement map of a water droplet impacting on the LIS with different surface temperatures as a function of oil kinematic viscosity.
LIS at different temperatures and measured the holding time with a small SA of below 5°. The results showed the durability decreased with increasing heating temperature and increased with increasing oil viscosity at the same temperature, as shown in Fig. 6a. At 100 °C, all the LIS can maintain the slippery property for more than 30 h, and even at 300 °C, LIS with oil viscosities of 100 cSt and 350 cSt can maintain slippery property for more than 5 h, much longer than a previous study. A heating/cooling treatment was further conducted to explore the stability of the LIS after cycle use. The LIS was first placed on a hotplate at 250 °C for 10 min, and then was immersed in water at 25 °C for 2 min to cool. Fig. 6b showed the critical SA variation as a function of the heating/cooling cycle. The LIS with viscosity of 50 cSt just maintained a low SA (below 5°) for two cycles, and then the SA rapidly increased with increasing number of heating/cooling cycles. The LIS with viscosity of 100 cSt maintained the low SA for five cycles, and then the SA rapidly increased just like that at 50 cSt. While for LIS with oil viscosity of 350 cSt, the low SA could be maintained for approximately 8 cycles, and then increased slowly with increasing treatment cycles. After 20 cycles, the critical SAs on the LIS with oil viscosities of 50 cSt and 100 cSt were all increased to above 55°, but it just increased to about 15° for oil viscosity of 350 cSt. In fact, the higher viscosity of silicone oil contains longer chain molecules, has a lower rate of evaporation at high temperatures, and thus results in a better stability. Although the slippery property of the LIS failed after long-time heat treatment, it could be repaired by adding silicone oil again. We added the silicone oil on the three LIS after 20 cycles, and all the LIS regained the slippery property as shown in Fig. 6 (the 21st cycle, marked by the black arrow), indicating the reusability of the prepared LIS even after long-term heat treatment.

The as-prepared LIS not only showed anti-wetting for room-temperature water, but also repelled hot water. Hot water (95 °C, stained with rhodamine) has a low surface tension (59.8 mN m⁻¹) and can wet the solid surface easily, as shown in Fig. 7a, in which amounts of water droplet were pinned on the hydrophobic OTS coated CESS. While, the LIS still showed anti-wetting for the hot water (Fig. 7b and ESI Video 3†). When the surface temperature was increased to 250 °C, the splashed water quickly became boiling on the OTS coated CESS, then spread to cover the surface, and finally stained the surface after complete evaporation (Fig. 7c). Just like the anti-wetting performance of room-temperature LIS for hot water, the LIS with surface temperature of 250 °C could completely repelled the splashed water as well (Fig. 7d and ESI Video 4†), indicating the stable slippery property of SS-based LIS for repellent liquid.

Besides excellent high-temperature resistance, our SS-based LIS in the present study also hold the advantages of a simple preparation process, good resistance to physical damage, and extensive applicability for different surface types, especially for the curved surface. Fig. 8a showed the slippery behavior of water on the scratched LIS with a tilt angle of ~5°. The stained water droplets quickly slid off and were not stopped by the scratches, as well for hot water (ESI Video 5†). A representative demonstration of the SS-based LIS on stainless steel eyebolts was presented to show the applicability for a curved surface. Fig. 8b and c showed the images of eyebolts after being immersed in dark ink with temperatures of 25 °C and 95 °C, respectively. We can see that nearly no ink wetted the eyebolt with LIS, while amounts of ink were pinned on the dry eyebolts (see ESI Video 6† for details).

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**Fig. 6** (a) Holding time of a small critical SA of below 5° of different silicone oils at different heating temperatures. (b) Variation of critical SA on the treated LIS with different kinematic viscosities after heating/cooling treatment cycles. Treatment conditions: the substrate was first heated on the hotplate at 250 °C for 10 min, and then was immersed in water at 25 °C for 2 min to cool. The black arrow marks adding oil at the 21st cycle to investigate the reusability of the LIS after heat treatment.

**Fig. 7** (a) Hot water (95 °C) stained with rhodamine was pinned on the OTS coated CESS. (b) While it could easily slide away on the LIS. (c) Hot water (95 °C) became boiling on the high-temperature (250 °C) OTS coated CESS and the surface was stained, (d) while it could easily slide away on the high-temperature (250 °C) LIS. The substrate was tilted to ~5°. Scale bar: 1 cm.
4. Conclusions

In summary, we have successfully fabricated a slippery liquid-infused surface based on CESS. Especially, the employed surface functionalization layer could withstand extremely high temperatures above 600 °C. The water sliding speed could be tuned by the kinematic viscosity of the infused oil. The sliding experiments showed that there were three movement states, i.e., sliding, rolling + sliding, and rolling, when water droplet was deposited on the surface, with increasing temperature. Similarly, there were also three types of rebounding and movement states under droplet impacting with increasing surface temperature. Heating/cooling experiments demonstrate the excellent high-temperature resistance and reusability of the as-prepared LIS. Furthermore, the SS-based LIS showed anti-wetting for hot water at both room-temperature and high-temperature. Resistance for physical scratches and applicability to curved surfaces were also demonstrated. We believe that this new, simple method to prepare the slippery surface with high-temperature resistance will provide an effective approach for anti-wetting of the surface involving industry, medical instruments, and other practical applications.

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Notes and references