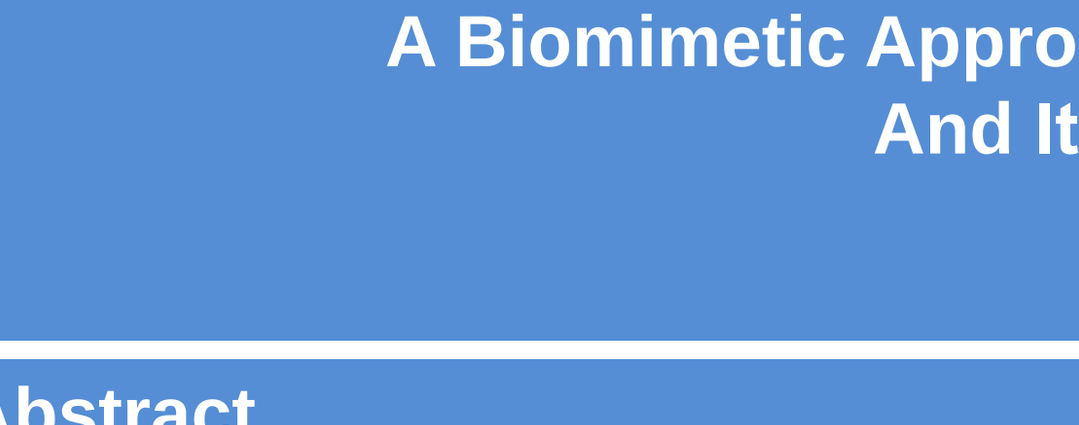
2017 International Bionic Innovation Competition

A Biomimetic Approach for Cutting Soft Matters And It's Application

Abstract

Mosquitoes are found to have the ability to insert their proboscises into human skin with astonishingly tiny force. This can be associated with the unique micro/nano saw teeth structure of their proboscises and the distinctive insertion manner—high frequency reciprocating saw cutting. Inspired by this, a biomimetic approach combining micro/nano toothed sawblade and reciprocating action was developed. This approach was used to cut biological soft tissue and hydrogel successfully.



Methods

Mo wire was polished and then immersed in acid solution. Afterwards, the wire was coated with the metal salts precursor of nanoparticles and after calcination biomimetic micro/nano toothed wire was obtained. The resultant wire was then installed on the medic reciprocating facility which can provide reciprocating action (Figure 1).

Results

The SEM images in figure 1 show that the micro/nano particles were implanted onto Mo wire successfully.

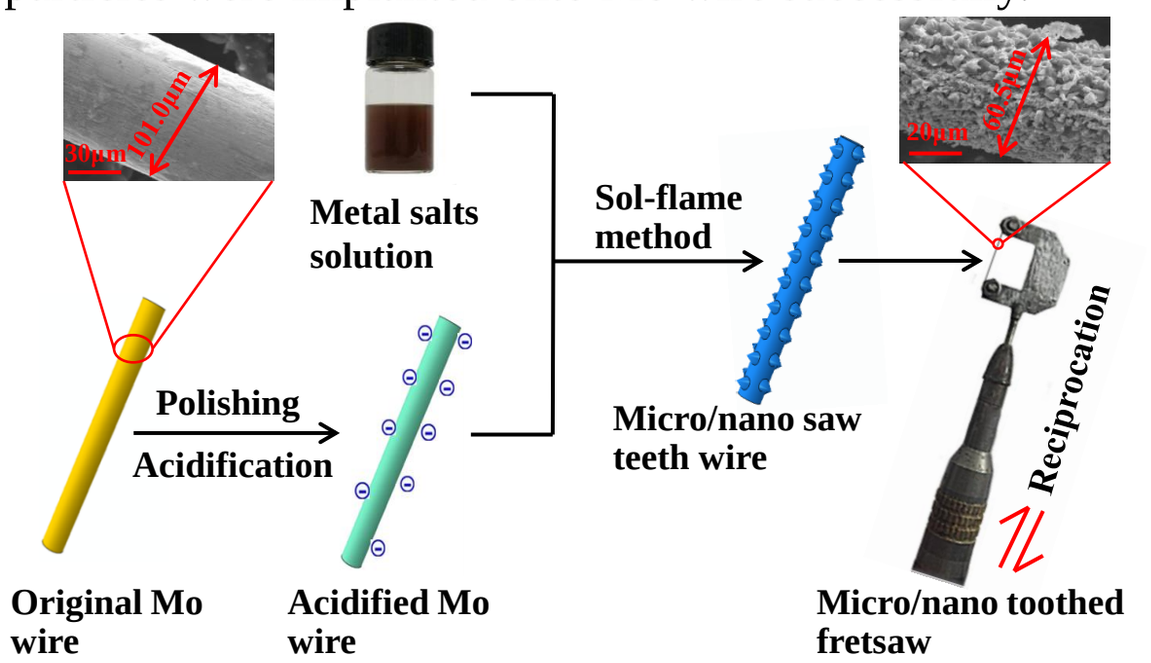


Figure 1. The preparation process of micro/nano toothed fretsaw

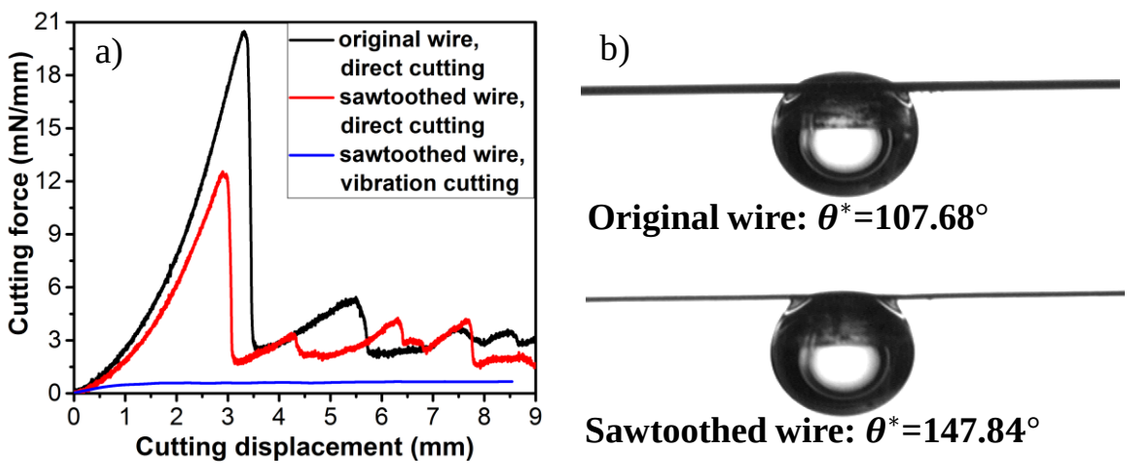


Figure 2. cutting forces-displacement curve (a) and apparent angle (b) of original wire and sawtoothed wire

Figure 2(a) indicates that cut-in force decreased substantially when the micro/nano toothed sawblade with reciprocating action was used to cut brain tissue and hydrogel.

This micro/nano sawtoothed wire was also found to approach super hydrophobic state which can reduce adhesion efficiently (Figure 2(b)).

Benefited from the excellent performance of this cutting approach, pure brain white matter (Figure 3(b)) and gray matter (Figure 3(c)) samples for mechanical test were prepared and the differences in their mechanical features can be distinguished (Figure 4). Hydrogel samples were also prepared by the fret saw with precise dimension (Figure 3(d)).

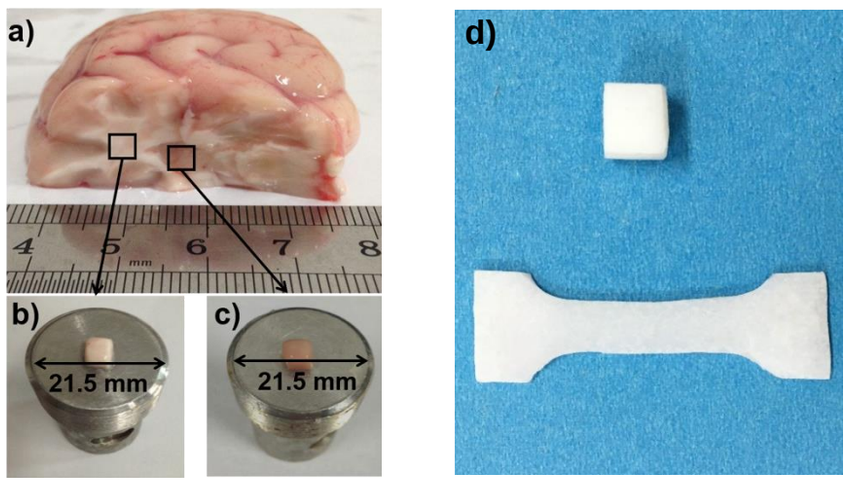


Figure 3. Photos of the white and gray matter samples ((a)~(c)) and hydrogel samples (d)

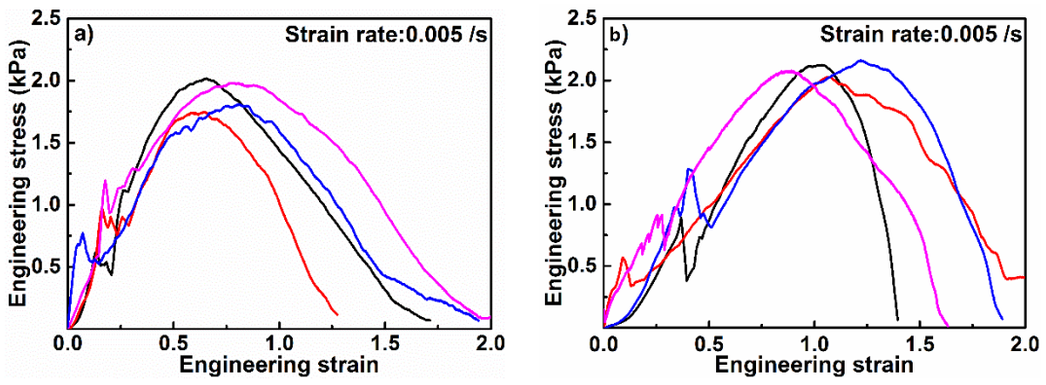


Figure 4. Stress-strain curve on white matter(a) and gray matter(b)

Conclusions

Inspired by the unique structure and insertion mode of the mosquito's proboscis, a novel biomimetic approach was developed. This biomimetic sawblade were used to obtain brain tissue and hydrogel specimens. The obtained results can provide referential information for surgery with less deformation, positional error and tissue damage.

Publications/patents or Rewards

Journal articles :

Micro/nano-particle decorated metal wire for cutting soft matter. Nanotechnology, 2016, 27(35), 355708

Cr^{3+} substituted spinel ferrite nanoparticles with high coercivity. Nanotechnology, 2016, 27(24), 245707

Novel nanoparticles with Cr^{3+} substituted ferrite for self-regulating temperature hyperthermia. Nanoscale, 2017, DOI, 10.1039/C7NR02356A

Effect of pillar height on the wettability of micro-textured surface: Volume-of-Fluid simulations. Int J Adhes Adhes, 2017, 74, 64-69

Frequency response and anti-shock mechanism of woodpecker's head structure. J Bionic Eng, 2014, 11(2), 282-287

Energy conversion in woodpecker on successive peckings and its role on anti-shock protection of brain. Science China: Technological Sciences, 2014, 57(7), 1269-1275

Mechanical response of brain stem in compression and the differential scanning calorimetry and FTIR analyses. J Appl Mech, 2016, 83(9), 091005

Differences in the viscoelastic features of white and grey matter in tension. J Biomech, 2016, 49(16), 3990-3995

Patents:

CN Patent: ZL201510418517.7

CN Patent: ZL201510006987.2

CN Patent: ZL201410805570.8

CN Patent: ZL201510467980.0