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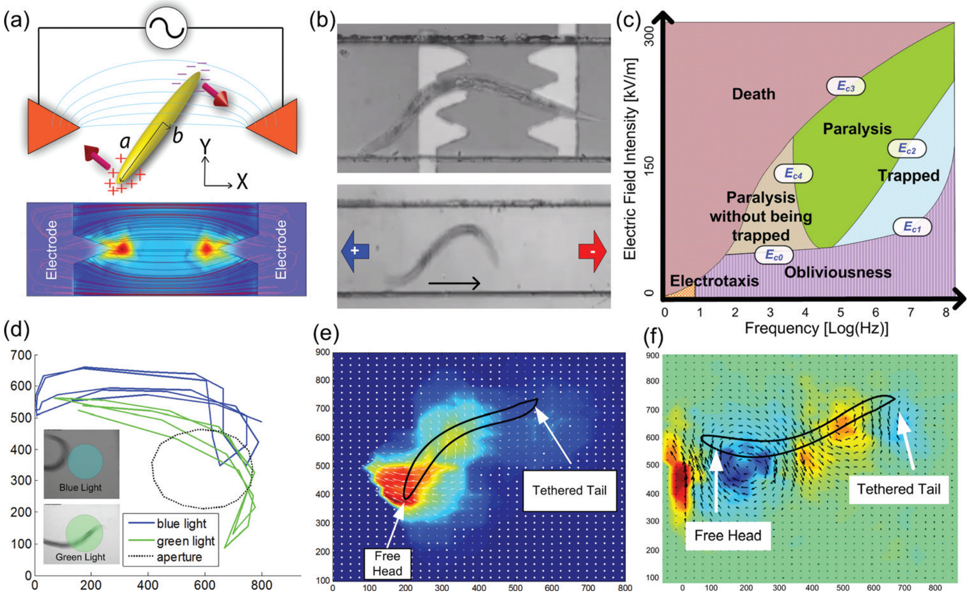

FIG. 1. (Color) The behaviors of *C. elegans* subjected to electric fields. (a) Schematic diagram of the dielectrophoretic (DEP) trap (top) and the simulated electric field (bottom). (b) (Top): An adult worm trapped by an electric field (40 kV/m, 1 MHz). (Bottom): A L4-stage worm autonomously swims towards the cathode of a DC field. (c) Conceptual phase diagram of worm's responses to electrical stimuli. (d) Photophobicity of a DEP trapped worm. (e) Instantaneous velocity field (arrows) measured from a DEP trapped worm. The color indicates the magnitude of the fluid velocity from low (blue) to high (red). (f) Instantaneous vorticity field induced by the worm in (e). The color ranges from negative vortex (blue) to positive vortex (red) (enhanced online) [URL: http://dx.doi.org/10.1063/1.3640009.1].

Electro-worming: The behaviors of *Caenorhabditis (C.) elegans* in DC and AC electric fields

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C. elegans is an attractive animal model for biomedical research and for studying animal locomotion. Electric fields offer a means to control nematodes' motion and to apply remote, non-contact forces. We study the behavior of nematodes as a function of electric field intensity and frequency. The deliberate attraction of nematodes towards the negative pole of an electric field has been known for some time and dubbed electrotaxis.[1] More recently, we have demonstrated that nematodes can be polarized with electric fields.[2]

We have carried out our experiments with wild type *C. elegans*. The DC field experiments were conducted in micro-conduits fabricated with Polydimethylsiloxane (PDMS), whose ends were equipped with electrodes. The AC field experiments were carried out with a pair of spiked electrodes patterned on a glass slide [Fig. 1(a)].

When a L2-stage or older nematode was introduced in a conduit and subjected to a *low* frequency, *low* intensity electric field, it swam deliberately toward the cathode [Fig. 1(b), bottom]. This electrotactic motion is neuron-mediated, and is not the result of any electrical forces. When the field frequency exceeds tens of kilo hertz, however, the nematode's neural system is no longer able to respond to the alternations in the electric field polarity.

When subjected to sufficiently intense and non-uniform electric fields that overcome the nematode's muscular power, the nematode polarizes, aligns with the field's direction, and experiences a net force directed towards the point of maximum electric field intensity [Fig. 1(b), top]. A nematode is trapped between two spiked electrodes when its body length exceeds the gap width between the electrodes. When the gap width is longer than a worm's body, however, only the worm's tail is tethered and the worm's head is free to move [Figs. 1(d)–1(f)].

A conceptual phase diagram delineating nematode's behavior as a function of frequency (ω) and intensity (E) was obtained [Fig. 1(c)]. The range of frequencies and intensities that apparently do not harm the worms is identified. After release, worms that were trapped in this particular E-ω range function as normally as untrapped worms. To examine the effect of trapping on neural functions, we monitored the trajectories traced by a nematode's head when illuminated with blue (480 nm) and green (545 nm) light. The nematode appeared to maintain its photophobicity [Fig. 1(d)]. The tethered worm pumps and stirs the fluid around it [Figs. 1(e) and 1(f)].

Better understanding of the effect of electric fields on nematodes would enable us to sort nematodes by size and muscular power, to control the nematodes' motion, and to construct nematode-based pumps and stirrers.

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