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Linear propulsion of gold-nickel-platinum nanojet steered by dual off-center nanoengines

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In this paper, a novel nanojet with dual off-center nanoengines consisting of Au, Ni and Pt is designed, as shown in Figure 1. Au and Ni are shaped as concentric disks with 12 μm in diameter. The thicknesses of Au- and Ni-disks are 0.2 and 0.1 μm, respectively. Two identically off-center Pt nozzle nanoengines form cylindrical chambers and are symmetrically distributed on the base of the Au-Ni disk. The diameter, bottom-thickness, wall-height and wall-thickness of the nozzle nanoengines are 3, 0.3, 1.5 and 0.3 μm, respectively. The propulsion mechanism for the Au-Ni-Pt nanojet is shown in Figure 2. Without the presence of hydrogen peroxide (H_2O_2), the nanojet suspended in deionized (DI) water is stationary. After the addition of H_2O_2 into DI water, oxygen (O_2) bubbles are generated at the Pt-surface (the nanojet and O_2 bubbles have a joint velocity of $v1$). The generated O_2 bubbles grow bigger (growing state). At this state, the nanojet and O_2 bubbles have a same velocity of $v2$. When O_2 bubbles reach a certain diameter, they detach from the surface of the nanojet (detaching state). The nanojet has a velocity of $v3$, while O_2 bubbles have a different velocity of $v0$. According to the Momentum Conservation Law and the Momentum Theorem, a driving force *F'drive* is generated, resulting from momentum change induced by the detachment of O_2 bubbles, to thrust the nanojet propelling forward. The nanojet is equipped with two identically and symmetrically distributed off-center nanoengines, resulting in the total driving force *Fdrive* is well aligned with the drag force *Fdrag*. Hence, the Au-Ni-Pt nanojet propels forward linearly. At steady state, the nanojet will continuously propel forward at a speed of *v*.

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