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Frugal Air Spark-like Plasma for Antimicrobial NO_x Generation

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Air discharge plasma operated at atmospheric pressure can be utilized for a wide variety of potential applications at low cost using robust, well-established technology. We term these applications *'frugal plasma,'* thereby suggesting this is an example of *frugal innovation* [1-2]. Air plasmas can be operated to generate either primarily ozone (O_3) or primarily nitrogen oxides (NO_x), among other chemical species.

We demonstrate and analyze the generation of nitrogen oxides and their antimicrobial efficacy using atmospheric air spark-like plasmas in simple, inexpensive devices. Spark-like discharges in air in a 1 L confined volume are shown to generate NO_x at an initial rate of over 2.2×10^{16} NO_x molecules/J dissipated in the plasma. An inexpensive power supply dissipating about 12 W in this confined volume generates ~3000 ppm NO_x in ten minutes. Over 90% of the NO_x is in the form of NO_2 after several minutes of operation in the confined volume, suggesting that NO_2 is the dominant antimicrobial component. The strong antimicrobial action of the NO_x mixture after several minutes of plasma operation is demonstrated by measuring rates of *E. coli* disinfection on surfaces and in water exposed to the NO_x mixture. The spark-like discharge systems generating these species can operate with inexpensive power supplies, simple automotive spark plugs, and relatively small sources of electricity that could be provided by compact solar panel systems to recharge modest-sized batteries. [3]

Some possible applications of frugal plasma generation of NO_x (perhaps followed by dissolution in water) include disinfection of surfaces, skin or wound antisepsis, and sterilization of medical instruments at or near room temperature. This is especially promising for circumstances in which conventional sterilization, disinfectant, or antiseptic supplies are not available, such as in emergency conditions, refugee camps, or isolated, low-resource settings in general.

Figure 1: *Photo of the 5-mm spark-like discharge in an automotive spark plug.*

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