Inspired by treefrog’s toe pads that show superior frictional properties, herein, an industrially compatible approach is reported to make an efficient dielectric tribosurface design using customizable nonclose-packed microbead arrays, mimicking the friction pads of treefrogs, in order to significantly enhance electrification performance and reliability of triboelectric nanogenerator (TENG). The approach involves using an engineering polymer to prepare a highly ordered large-area concave film, and subsequently the molding of a convex patterned triboreplica in which the concave film is exploited as a reusable master mold. A nature-inspired TENG based on the patterned polydimethylsiloxane (PDMS) paired with flat aluminum (Al) can generate a relatively high power density of 8.1 W m⁻² even if a very small force of ≈6.5 N is applied. Moreover, the convex patterned PDMS-based TENG possesses exceptional durability and reliability over 25 000 cycles of contact-separation. Considering the significant improvements in power generation of TENG; particularly at very small force, together with cost-effectiveness and possibility of mass production, the present methodology may pave the way for large-scale blue energy harvesting and commercialization of TENGs for many practical applications.