Demixing in simple fluids induced by electric field gradients

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Phase separation in liquid mixtures is mainly controlled by temperature and pressure, but can also be influenced by gravitational, magnetic or electric fields. However, the weak coupling between such fields and concentration fluctuations limits this effect to extreme conditions[1–3]. For example, mixing induced by uniform electric fields is detectable only at temperatures that are within a few hundredths of degree or less of the phase transition temperature of the system being studied[4–7]. Here we predict and demonstrate that electric fields can control the phase separation behaviour of mixtures of simple liquids under more practical conditions, provided that the fields are non-uniform. By applying a voltage of 100 V across unevenly spaced electrodes about 50 μm apart, we can reversibly induce the demixing of paraffin and silicone oil at 1 K above the phase transition temperature of the mixture; when the field gradients are turned off, the mixture becomes homogeneous again. This direct control over phase separation behaviour depends on field intensity, with the electrode geometry determining the length-scale of the effect. We expect that this phenomenon will find a number of nanotechnological applications, particularly as it benefits from field gradients near small conducting objects.