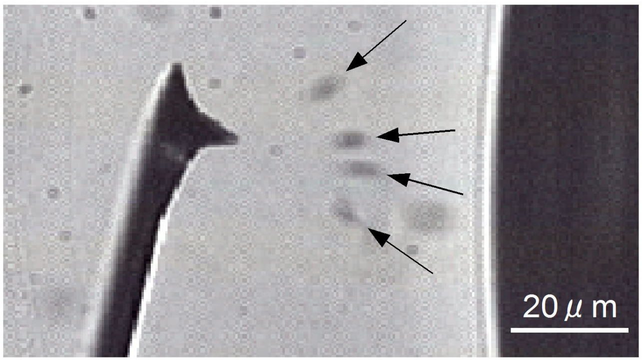
Supplementary Information

Supplementary Information 1

Formation of an unsymmetrical electric field and an upward-flowing 1-butanol current.



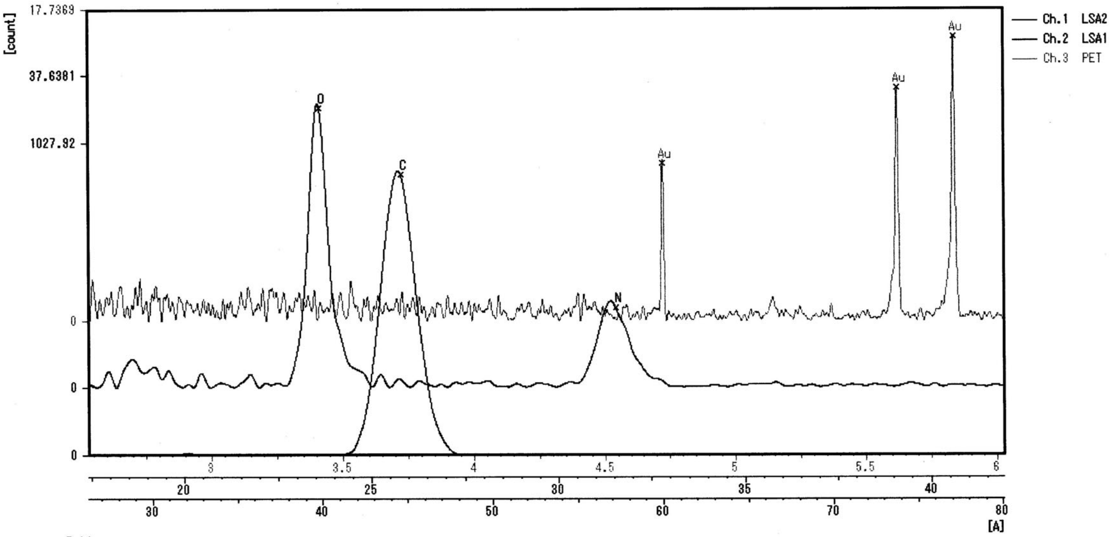
The formation of an unsymmetrical electric field between the tip of the AFM tip and the tungsten electrode was determined by observing the movement of the upward-flowing 1-butanol current. When an electric potential of 1.2kV was applied between the AFM tip and the tungsten electrode, several microscale particles were observed (black arrows). The microscale particles were found to move toward the tip of the AFM tip. The AFM tip became completely covered with particles. The radial movement of the particles from the surface of the 1-butanol to the tip of the AFM tip indicated that the most intense electric field was generated at the tip of the tip. Clearly, the dielectric 1-butanol particles were attracted toward the tip of the AFM tip, in the direction of the electric field.

The generation of an intense electric field at the tip of the AFM tip can be understood from the properties of electric lines of force. An electric field can be represented by electric lines of force. A line of force can store 1/2 E of electric energy (E represents the magnitude of an electric field) on the line per unit length.[4,5] The electric lines of force are formed between electrons on the negative electrode and nuclei on the positive electrode. Since each line has 1/2 E of electric energy per unit length, the lines tend to decrease the distance between electrons and nuclei to reduce the electric energy. The tendency causes the electrons to move from the nuclei toward the closer area, which is the tip of the AFM tip in our apparatus. Therefore, the density of the electrons at the tip of the AFM tip will be greater than at other areas of the tip. This generates a more intense electric field at the tip of the AFM than in other areas. The same argument can be made from the perspective of electric momentum on the electric lines of force, which tend to reduce tension by shortening the distance between electrons and nuclei. (See **Apparatus** section).

Supplementary Information 2

Weight percentages of elements contained in the 1-butanol polymer.

File Name : 11
File Comment :
Position Comment :
Acc.V(kV) = 15.0, Beam Size(um) = 30, S.C.(uA) = 0.0300



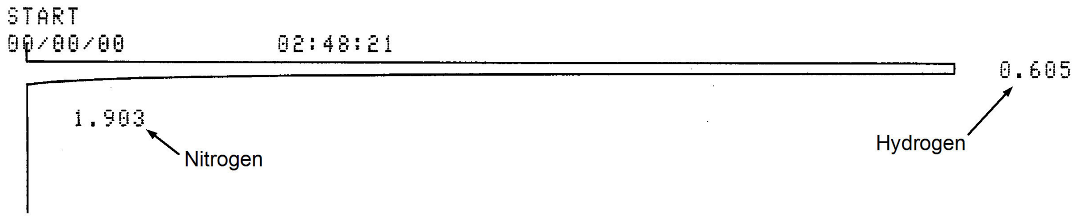
-------- Ratio --------
[Coating Element = Au]

No	ELE.		Crystal	W.L.(A)	PKI-BGI	STD(I)	I-Ratio	WT(%)
1	C	Ka	LSA2	44.7000	1002.69	1627.19	0.6162	67.780
2	N	Ka	LSA1	31.6000	15.26	66.99	0.2278	25.056
3	O	Ka	LSA1	23.6200	45.09	692.37	0.0651	7.164
TOTAL								100.000

Electron Probe Microanalysis (EPMA) revealed that 1-butanol polymer on an AFM tip contained 25 weight percent of nitrogen, 67.8 weight percent of carbon, and 7.2 weight percent of oxygen. The ratio of the number of atoms per unit mass is 12 : 4 : 1 for carbon : nitrogen : oxygen. The data demonstrated that nitrogen molecules in air were fixed to 1-butanol polymer. AFM tip, DF-20 (Au-coated silicon tip) SII.

Supplementary Information 3

Data of the gas chromatography of the bubbles produced on the negative AFM tip during the 1-butanol polymerization.



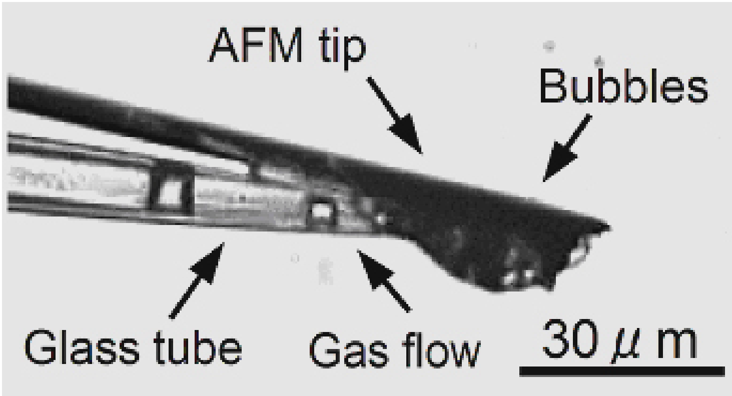
CHROMATOPAC C-R6A FILE 0
SAMPLE NO 0 METHOD 41
REPORT NO 2859

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	0.605	1386036	S		99.833	Hydrogen
2	1.903	2318	T		0.1669	Nitrogen
	TOTAL	1388354			100	

Data of the gas chromatography obtained from the bubbles on the negative AFM tip during 1-butanol polymerization. Only the ratio of the concentration of hydrogen and nitrogen is addressed in this data, since the machine was not suitable for detecting all the gasses produced during the 1-butanol polymerization. Gas chromatography detected the hydrogen concentration to be 99 times more dense than nitrogen. Gas chromatograph, GC-14BPTF, Shimadzu.

Supplementary Information 4

Production and sampling of gas bubbles on the AFM tip.



An example for sampling gas bubbles generated from the liquid 1-butanol polymer produced on the AFM tip. Sharpened glass tubes made of borosilicate glass and ranging in diameter from 1 to 10 μm depending on the viscosity of the liquid were used to sample the gas bubbles. Bubbles produced in viscous regions of the AFM tip were sampled slowly. Bubbles produced in regions of low viscosity rapidly entered the glass tubes, probably due to the pressure or temperature of the bubbles. The chemical composition of the gas bubbles is described in the text.