plasma

MDPI

S1. Sealed Chamber Construction

A sealed pressure chamber for gas testing was fabricated by MI Engineering Ltd., Lye, UK from mild steel and consisted of a box and a flat lid, drilled with untapped M6 holes for bolting the lid onto the box. Steel reinforced 3 mm sheet rubber (RS Components Ltd, Corby, UK) was used to form a gasket seal between the lid and the box. Inside the walls of the box, two tapped holes were cut to allow for passage of light in and out of the chamber via UV-fused silica windows (Thorlabs WG40530 and WG41050, Ely, UK) mounted in lens tubes (Thorlabs SM05L10 Ø12.7 mm and SM1L10 Ø25.4 mm, Ely, UK). To tap these holes it was necessary to purchase the bespoke taps from Thorlabs (Thorlabs 83373–Imperial Tap 0.535"–40 SM05 and Thorlabs 97355–Imperial Tap 1.035"–40 SM1, Ely, UK). The UV fused silica windows were fitted into the lens tubes with 2 rubber O-rings and sealed with ethyl cyanoacrylate (B&Q Plc, Eastleigh, UK).

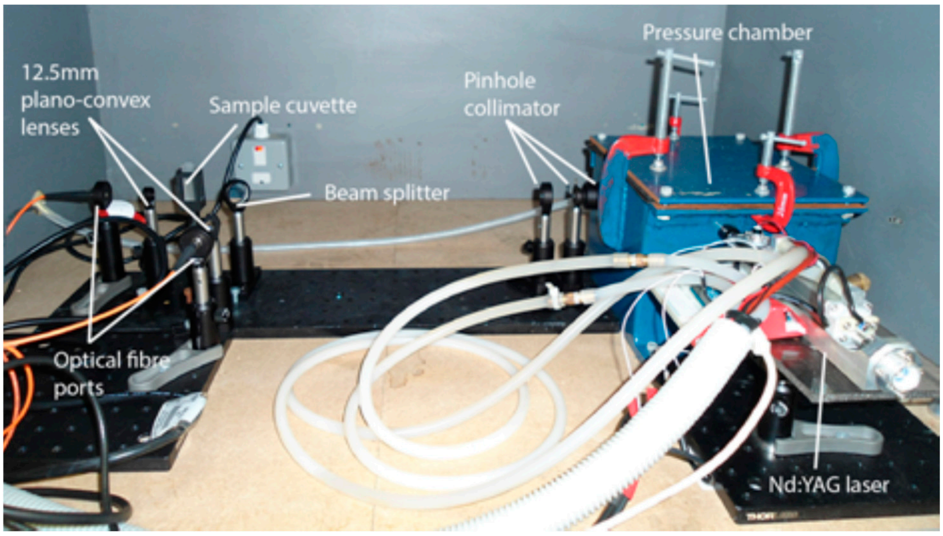

Figure S1. A photograph of the assembled plasma spectrometer instrument. The major components are labelled.

The chamber was also fitted with a ¼" BSP ball valve for pressure release, a ¼" BSP 0–10 bar pressure gauge and a 4 bar Niezgodka Type 66 Open Discharge Safety Relief Valve safety valve (RS Components Ltd, Corby, UK). The pressure gauge reads the chamber pressure relative to atmospheric pressure (gauge pressure), therefore a reading of 1 bar on the gauge represents an absolute pressure of 2 bar. Each of the threads cut in the chamber were sealed with thread sealant. The likeliest places for the chamber to fail due to excessive pressure were the two windows contained in lens tubes that allow light in and out of the chamber but the chamber was not destruction tested and so the maximum working pressure of the chamber remains unknown. The two Czerny-Turner spectrometers (Thorlabs CCS200/M, Ely, UK) amounted to the vast majority of the total cost of the instrument (£4,500 of a total cost of ≈ £6,500 GBP, March 2016).

S2. Analogue-digital Signal Conversion

The analogue signal from the photodiode was converted by the microcontroller into a 10 bit (0–1024) digital variable. The photodiode was placed close to the laser flash-lamp so that the photodiode would receive light from the laser pumping flash. If the intensity of light impinging on the photodiode generated a 10-bit digital signal that was greater in value than 600, the microcontroller waited 475 ms (if the pulse rate was 2 Hz) before switching on a +5 V digital signal for 10 ms to one of its digital output pins. This digital output pin was connected to the triggers of each of the spectrometers and triggered the start of the 50 ms integration time when the +5 V signal was received. After 10 ms the microcontroller was programmed to switch the +5 V signal back to 0 V and continue to read the analogue input from the photodiode.

S3. Derivation of Expression for Absorbance.

The absorbance of a sample is:

$$Absorbance = \log_{10}\left(\frac{I_T}{I_A}\right)$$

I_T was unknown but was determined from I_R and the wavelength dependent transmittance of the beam splitter T_λ. T_λ was determined by recording I_T and I_R in the absence of a sample. In the absence of a sample $I_T = I_A$ and T_λ is:

$$\text{Transmittance of beamsplitter } T_\lambda = \frac{I_T}{I_T + I_R}$$

$$I_T = \frac{T_\lambda}{1 - T_\lambda} I_R = C_\lambda I_R$$

$$C_\lambda = \frac{I_T}{I_R}$$

The variable C_λ was then used to calculate the transmitted integrated intensity from the reflected integrated intensity using $I_T = C_\lambda I_R$. The mean C_λ and standard deviation σC_λ as a function of wavelength were determined by recording I_R and I_T in the absence of a sample for 300 plasma pulses. Sample absorbance spectra were then determined by measuring the integrated intensities I_A and I_T with a sample in the beam:

$$Absorbance\ of\ sample\ Abs_\lambda = log_{10}\left(\frac{I_T}{I_A}\right) = log_{10}\left(\frac{C_\lambda I_R}{I_A}\right)$$

The standard deviation in an absorbance measurement was calculated from σC_λ:

$$Error\ in\ absorbance\ of\ sample\ \sigma Abs = \left(\frac{\partial Abs_\lambda}{\partial C_\lambda}\right)\sigma C_\lambda$$

$$\frac{\partial Abs_\lambda}{\partial C_\lambda} = \frac{1}{C_\lambda}$$

$$\sigma Abs = \frac{\sigma C_\lambda}{C_\lambda}$$

S4. The Effect of Lysozyme Concentration Over Time in The Presence of Heparin.

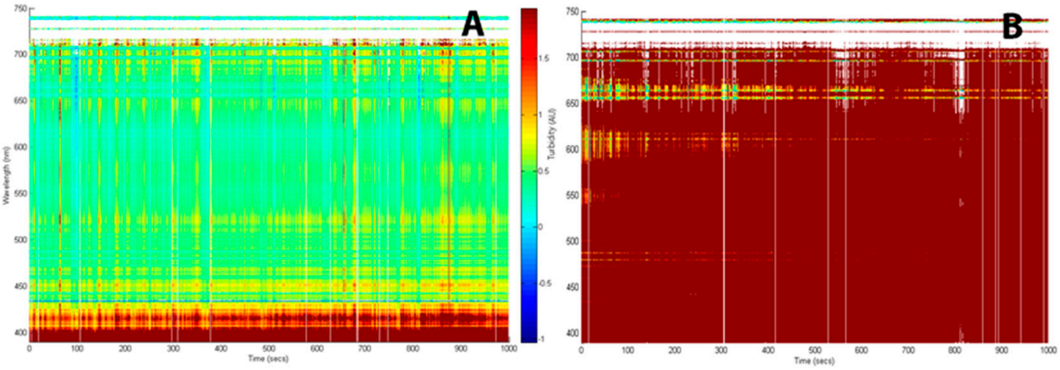

Figure S2. Graphs of the turbidity of aggregating lysozyme in the presence of pharmaceutical heparin, pH 9.3, at 1 mg/mL (**A**) and 3 mg/mL (**B**). The graphs are constructed from sequential absorbance spectra recorded at a rate of 1 Hz.

S5. Results of Emission Tests for Helium and Neon.

The spectra display considerable line emission and for many wavelengths the line emission peaks are greater than the highest measurable intensity (>1), prohibiting the determination of absorbance values using these gases at these wavelengths.

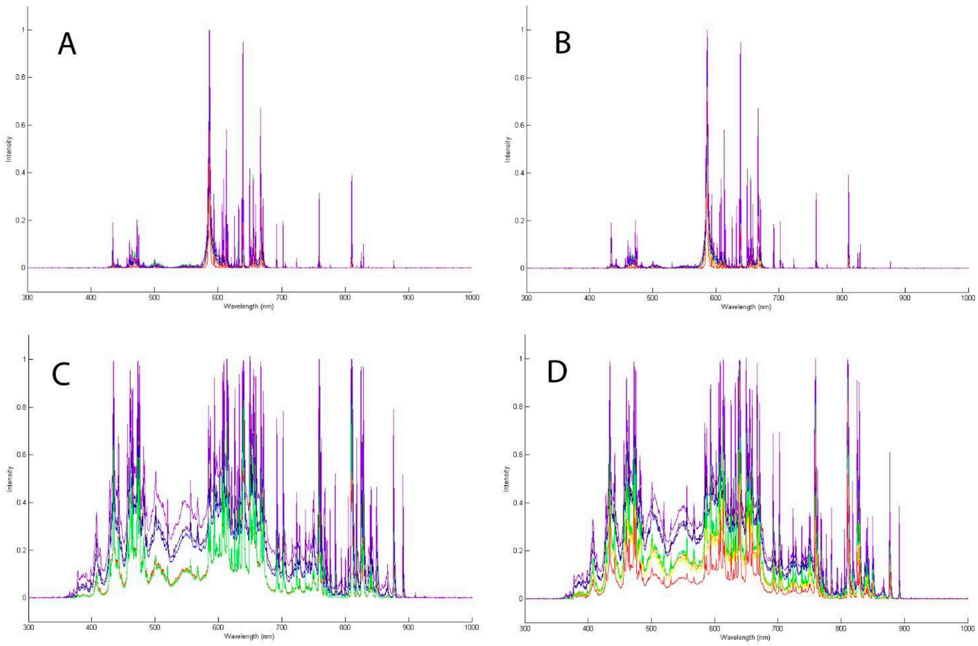

Figure S3. A–D Mean emission spectra of the laser-induced plasma formed over a range of pressures in: **A.** He **B.** He with frequency doubling to λ = 532 nm. **C.** Ne **D.** Ne with frequency doubling to λ = 532nm. All spectra are the average emission over 600 laser pulses. Key: Red—1 bar, Orange—1.2 bar, Yellow—1.4 bar, Green—1.6 bar, Blue—1.8 bar, Dark Blue—2 bar, Purple—2.2 bar.

S6. Performance of He and Ne for plasma generation.

Table S1. The performance of He and Ne for generating laser-induced plasmas over a range of pressures.

Gas	Absolute Pressure (bar)	Average Plasma Intensity (0–1)	Standard Deviation of Intensity	Number of Pulses of Intensity > 0.01	Percentage Successful Plasma Formation
He	1	0	Null	42	7%
	1.2	0.01511	0.019	269	44.8%
	1.4	0.039	0.031	488	81.3%
	1.6	0.054	0.037	539	89.8%
	1.8	0.023	0.022	392	65.3%
	2	0.036	0.03	497	82.8%
	2.2	0.053	0.038	529	88.2%
Ne	1	0.182	0.111	560	93.3%
	1.2	0.178	0.116	569	94.8%
	1.4	0.177	0.109	582	97%
	1.6	0.376	0.127	600	100%
	1.8	0.348	0.115	600	100%
	2	0.392	0.148	600	100%
	2.2	0.516	0.153	600	100%