"Endohedral Fullerenes"

Fall 2003

Danielle Garrett

Abstract:

The purpose of this research was to produce sodium filled endohedral fullerenes by injecting sodium ions into C_{60} molecules by laser ablation. After reproducing the experiment four times, it was found that $Na@C_{60}$ (sodium endohedral fullerene) was not produced. However, many unexpected molecules were found in the spectra: (molecules found; spectra #) (C_{56} and C_{60}; 1), (C_{58}, C_{60} and $C_{60}O$; 2), (C_{58}, C_{60}, $C_{60}O$ and $C_{60}O_2$; 3), (C_{58}, $C_{58}O$, C_{60}, $C_{60}O$, $C_{59}O_2$, $C_{60}O_2$, $C_{60}O_3$ and $C_{60}O_4$; 4), (C_{58}, C_{60}, $C_{59}O$, $C_{60}O$, $C_{59}O_2$ and $C_{60}O_2$; 5), (C_{54}, C_{56}, C_{58}, C_{60}, $C_{59}O_2$, $C_{60}O_2$, $C_{60}O_3$, $C_{59}O_6$ and C_{70}; 6) and (C_{60}, $C_{60}O$, $C_{60}O_2$, $C_{60}O_3$ and $C_{60}O_4$; 7). After analyzing the spectra, the resolution was calculated and found to be 1670 ± 178.

Introduction:

The purpose of this research was to try to form endohedral fullerenes by injecting sodium ions into C_{60} molecules using a laser ablation technique. Endohedral fullerenes are molecules in which an atom or several atoms have been captured within a fullerene's caged structure. Endohedral fullerenes are typically made in two ways. Firstly, they can be produced by striking an arc between graphite electrodes in an inert gas environment. Secondly, they can be produced by bombarding a graphite target containing the element to be entrapped in the fullerene with a high-powered laser. In both of these techniques, a sizeable quantity of carbon soot is produced. Only a minute portion of the product contains endohedral fullerenes.

Fullerenes are closed hollow caged structures that consist only of carbon atoms. Every carbon atom in the structure is bonded to three other carbon atoms. Robert Curl, Harry Kroto and Richard Smalley first discovered fullerenes in 1985. Curl and Smalley were working at Rice University trying to reproduce the aggregation of carbon atoms in cool giant red stars. However, in this process, they found traces of fullerenes: "Carbon plasma generated by laser vaporization of graphite spontaneously formed large carbon clusters upon cooling, and mass spectrometric analysis of the products showed that the cluster ions C_{60} and C_{70} were particularly stable."[3] It was not until 1990 that observable quantities of fullerenes were produced by researchers at the Max Planck Institute in Germany. Noticeable amounts of C_{60}, C_{70} and other bigger fullerenes were discovered in the soot produced by arc vaporization of graphite.

After laser ablation, the products can by analyze using matrix assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS).

In MALDI-TOF MS, a laser is pulsed at a surface containing the sample (analyte) mixed with a chemical matrix. A matrix is picked that will strongly absorb the energy from the laser light. MALDI-TOF separates ions based on their mass/charge ratio. A pulse of laser light is used to ionize the molecules. A pulsed electric field then accelerates all ions to the same kinetic energy into a region free from the electric field:

$$\text{Kinetic energy} = 1/2mv2 = qV,$$

where m = mass, v = velocity, q = charge and V = applied voltage.

Lighter ions have a higher velocity than heavier ions. Therefore, lighter ions reach the detector sooner. The flight time is calculated by dividing the mass by their charge:

$$t = L/(2V/(m/q))^{1/2} = L/v,$$

where t = flight time and L = the length of the tube.

During desorption and ionization of the sample, some of the analyte can leave the matrix surface with a minute quantity of variable kinetic energy as well as the energy obtained by acceleration. The kinetic energy is the cause of band broadening in the spectra: "This variable kinetic energy has the effect of "smearing" the mass-to-charge ratio of a specific analyte fragment over a small time range, decreasing the signal-to-noise ratio and broadening the analyte bands."[4] However, this band broadening can be practically eliminated in two ways. First, delayed pulse extraction can be used to help eliminate band broadening. In delayed pulse extraction, an acceleration voltage is applied in a brief high voltage pulse a short time after the desorption/ionization laser has been triggered. Second, changing the time-of-flight geometry by adding a reflectron to the end of the flight tube and by moving the detector, the ion band will be focused. A reflectron is made up of many electrostatic fields. These fields gather and redirect the

ions: "Ions with a given *m/z* slow down as they approach the reflectron mirror, focus into a tighter packet, and are then repelled either at an angle toward a detector at the end of a second stage of flight tube or backward along the same tube to a detector placed near the ion source."[4] Therefore, by reducing the effects of the differences in the original kinetic energy, time-of-flight broadening is reduced. Reflectrons can also enhance the resolution and increase the mass accuracy by doubling the flight path in time-of-flight mass spectrometry.

Resolution is a dimensionless ratio $m/\Delta m$, where m is mass and Δm is the full-width-half-maximum of the mass peak. Low mass resolution refers to a $m/\Delta m$ ratio that is just high enough to separate ions differing by one amu (atomic mass unit). Often, high mass resolution is required to separate ions that have almost identical masses or masses with high molecular weight. Using the equation $m/\Delta m$, resolution can be calculated from spectra:

$$\text{Resolution} = m/\Delta m = 2T/\Delta T,$$

$$\text{here } \Delta T = 1/2\ T\Delta m/m = \tfrac{1}{2}\, k\Delta m/m^{1/2} \text{ and } k = L/(2eV)^{1/2},$$

where ΔT = change in flight time, T = flight time, Δm = change in mass, m = mass, L = length of flight path, e = electron charge and V = voltage

Experimental Procedure:

A solution of C_{60} was prepared using 0.069g of C_{60} and toluene. The metal tip and metal plate were removed from the ionization pump chamber (Figure 1). The metal tips were coated with twenty-five layers of the C_{60} solution. Remove the faceplate from

the metal plate. Smear the plate with solid sodium. Place the faceplate back over the sodium. Place the metal tips and sodium-coated plate back in the vacuum chamber. Turn the mechanical pump on. Allow the pump to run for at least twenty-four hours in order to let the pressure drop to 10^{-2} Torr. Set the wavelength of the Nd:YAG (neodymium: yttrium-aluminum-garnet) laser to 532 nm. Turn the laser power to approximately 40-45 Joules/Pulse in order to focus the laser beam through the 25-cm focal length lens onto the sodium coated plate. Once the laser beam is focused, turn the power up to 80 milli-Joules/Pulse and turn the amplifier on to 20 milli-Joules/Pulse. Allow the laser to run for ten minutes. After turning the laser off, remove the metal tip and scrape the product off into a small vial. Then rinse the tip then off over the vial with toluene. Dilute the product in the vial with toluene.

The next step is to analyze the product sample using MALDI-TOF MS. First, clean the sample plate. Wash the plate with a detergent and then rinse it with water. Next, rinse the plate with methanol. After that, dry the plate with a stream of nitrogen air. Finally, place the plate in a vacuum-sealed container to dry completely. Place 1μL of the sample onto one of the spots on the sample plate. Repeat this on two or three more spots on the sample plate. Place the plate back in the vacuum-sealed container to make sure all the sample spots are completely dry. Then insert the sample plate into the mass spectrometer. Apply the laser to each separate sample spot in order to ionize the molecules. After firing the laser several times to one spot, move the laser to the next spot containing the sample. Repeat this procedure with the laser until all sample spots have been shot by the laser and enough data has been compiled to form an accurate spectrum of the sample.

Results:

After running the experiment four times, it was concluded that $Na@C_{60}$ molecules (sodium endohedral fullerenes) were not produced. However, several interesting compounds were found to be in the spectra. In the first set of spectra, C_{56} and C_{60} were discovered. In the second set of spectra, C_{58}, C_{60} and $C_{60}O$ were found. C_{58}, C_{60}, $C_{60}O$ and $C_{60}O_2$ were found in the third spectrum. In the fourth spectrum, C_{58}, $C_{58}O$, C_{60}, $C_{60}O$, $C_{59}O_2$, $C_{60}O_2$, $C_{60}O_3$ and $C_{60}O_4$were found. In the fifth set of spectra, C_{58}, C_{60}, $C_{59}O$, $C_{60}O$, $C_{59}O_2$ and $C_{60}O_2$ were discovered. C_{54}, C_{56}, C_{58}, C_{60}, $C_{59}O_2$, $C_{60}O_2$, $C_{60}O_3$, $C_{59}O_6$ and C_{70} were found in the sixth set of spectra. Finally, C_{60}, $C_{60}O$, $C_{60}O_2$, $C_{60}O_3$ and $C_{60}O_4$were were discovered in the seventh spectrum. The seventh spectrum is the blank. It contained only the C_{60} solution. There are several plausible explanations for the presence of many of these molecules in the spectra collected. The presence of smaller fullerenes such as C_{54}, C_{56} and C_{58} could be due to the high power of the laser. The high power would cause the molecules to be in vibrationally excited states. If the molecules were excited enough, carbons would be spit off from the original molecule. The presence of C_{70} could be caused by ion bombardment. If this were the case, two C_{60} molecules would combine to form C_{70}. The presence of oxygen in the samples can be explained by the ease with which C_{60} is oxidized. Since only the mechanical pump was used, it is possible that the vacuum chamber had an air leak, therefore, exposing the C_{60} to oxygen. Finally, fullerenes smaller than C_{60} with attached oxygen atoms could have been produced by the oxygen knocking off a carbon atom and adding itself to the molecule.

By using the equation

$$\text{Resolution} = m/\Delta m.$$

where m = mass and Δm = change in mass, the resolution from the various spectra was calculated. After taking an average of several measurements (see Table 2), the resolution was determined to be 1670 ± 178. Improved resolution is achieved be delayed pulse extraction. Delayed pulse extraction reduces the resolution loss caused by the variable velocities of the ions as they are desorbed from the sample. Lower-velocity ions undergo a larger accelerating velocity than higher-velocity ions once the delayed pulse extraction voltage is applied. Lower velocity ions draw alongside the higher-velocity ions of equal mass by the time the ions get to the detector if the correct time delay is chosen. Delayed pulse extraction diminishes the broadness of arrival times and increases the resolution.

Conclusions:

There are several things that could have been done to improve the experimental procedure and possibly increase the chances of successful results. First, the wavelength on the Nd:YAG laser could have been set to 355nm. Decreasing the wavelength from 532nm to 355nm would increase the energy of the ions:

$$\lambda = h/mv = hc/E,$$

where λ = wavelength, h = Planck's constant, m = mass, v = velocity, c = speed of light and E = energy. Increasing the energy and velocity of the ions would increase the chance that they would penetrate the C_{60} molecules. Secondly, the diffusion pump should have been used. Diffusion pumps capture gas molecules by vaporizing and condensing a special type of oil. Diffusion pumps can attain vacuum pressures to the order of 10^{-4}-10^{-7} mbar. This low pressure would keep the C_{60} and sodium from rapidly oxidizing. More importantly, the relatively high pressure of background gas will cause energy loss of the

Na+ ions resulting in low energy ions hitting the C_{60}. Next, when performing MALDI-TOF MS, a matrix could have been used instead of merely placing the collected product on the sample plate. The matrix absorbs photon energy from the laser. Therefore, since the analyte does not directly absorb the energy, the matrix helps keep the analyte from fragmenting or decomposing. Finally, a different fullerene solution could be used to coat the metal tip. The C_{60} molecule could be replaced with a larger fullerene: "Even though C_{60} is the most common fullerene, few endohedral materials have a C_{60} cage because it is fairly small inside. Most of these materials are made out of C_{82}, C_{84}, or even higher fullerenes."[1]

Despite these changes, the probability of producing an endoherdal fullerene still seems rather low. Not only is it difficult to get the atoms inside the caged molecule, but it is also hard to get them to remain inside. There are only a few atoms that are known to form stable endohedral fullerenes. Most molecules will break apart because the chemical bonds will not develop at the right angles. It has been found that it is not easy to get an atom inside a fullerene once the cage has already formed. Therefore, it would be better if the atoms could be placed inside as the cages are forming: "the cage must "wrap around" the atom as it comes together."[1] Currently, there is not much data available to study on the production of endohedral fullerenes. Few experiments have been conducted because endohedral fullerenes are still made in rather small amounts. Efficient methods of production have not yet been discovered.

In spite of the lack of information available on endohedral fullerenes, they could have a promising future in the field of medicine – "from delivery of radioisotopes, to cancer cells, to MRI."[2] Fullerenes have several advantages that would make them

beneficial in the medical field. First, anything that is located within the fullerene cage would be protected from the body. Second, the body has a reasonably high tolerance for carbon. Finally, many fullerenes are small enough that once in the system, they could be easily expelled through the kidneys. One potential application would be to place a radioactive tracer atom inside a fullerene. Once injected into a person's bloodstream, the blood flow could be monitored. Another possible use would be to utilize the fullerene cage to carry a drug inside the body. Then, after a certain amount of time has passed, the drug would be released. The drug release would most probably occur by dissolution or breakdown by chemicals in the body. However, the medical field is still many years away from turning these ideas into practical applications.

Danielle Garrett

Table 1. Resolution Calculations

	mass (m)	change in mass (Δm)	resolution (m/Δm)
	720.257	0.3812	1889
	736.3008	0.4750	1550
	720.3321	0.4625	1557
	740.3119	0.4750	1559
	804.2943	0.5437	1479
	722.2314	0.4500	1605
	724.2748	0.3813	1900
	752.2321	0.3812	1973
	736.3177	0.4625	1592
	720.2123	0.4500	1600
Average			1670
Standard Deviation			178

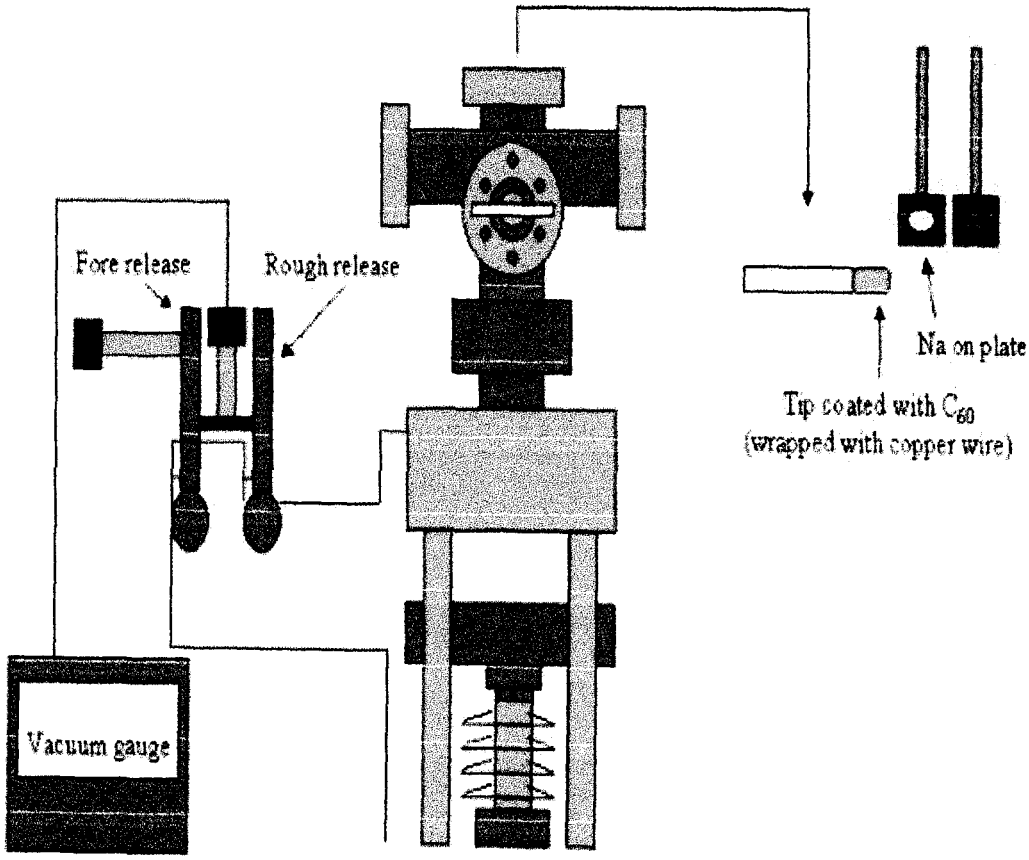
m = mass
Δm = change in mass = width of peak at 1/2 the height

Table 2. Molecules Found in Spectra

Spectra #	1	2	3	4	5	6	7
	10/27/03 positive ion sample	10/27/03 negative ion sample	11/7/03 negative ion sample	11/7/03 negative ion sample	11/17/03 negative ion sample	11/17/03 negative ion sample	11/17/03 negative ion blank
	C_{56}	C_{58}	C_{58}	C_{58}	C_{58}	C_{54}	C_{60}
	C_{60}	C_{60}	C_{60}	$C_{58}O$	C_{60}	C_{56}	$C_{60}O$
		$C_{60}O$	$C_{60}O$	C_{60}	$C_{59}O$	C_{58}	$C_{60}O_2$
			$C_{60}O_2$	$C_{60}O$	$C_{60}O$	C_{60}	$C_{60}O_3$
				$C_{59}O_2$	$C_{59}O_2$	$C_{59}O_2$	$C_{60}O_4$
				$C_{60}O_2$	$C_{60}O_2$	$C_{60}O_2$	
				$C_{60}O_3$		$C_{60}O_3$	
				$C_{60}O_4$		$C_{59}O_6$	
						C_{70}	

Danielle Garrett

Figure 1. Vacuum Ionization Pump



Vacuum Ionization Pump

Danielle Garrett

Figure 2. Vacuum Ionization Pump

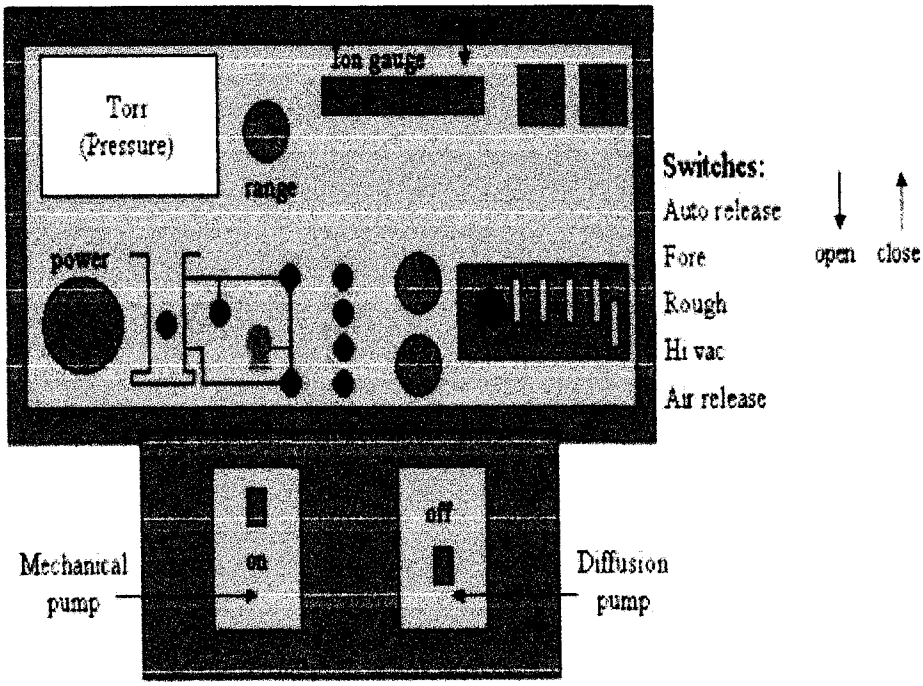
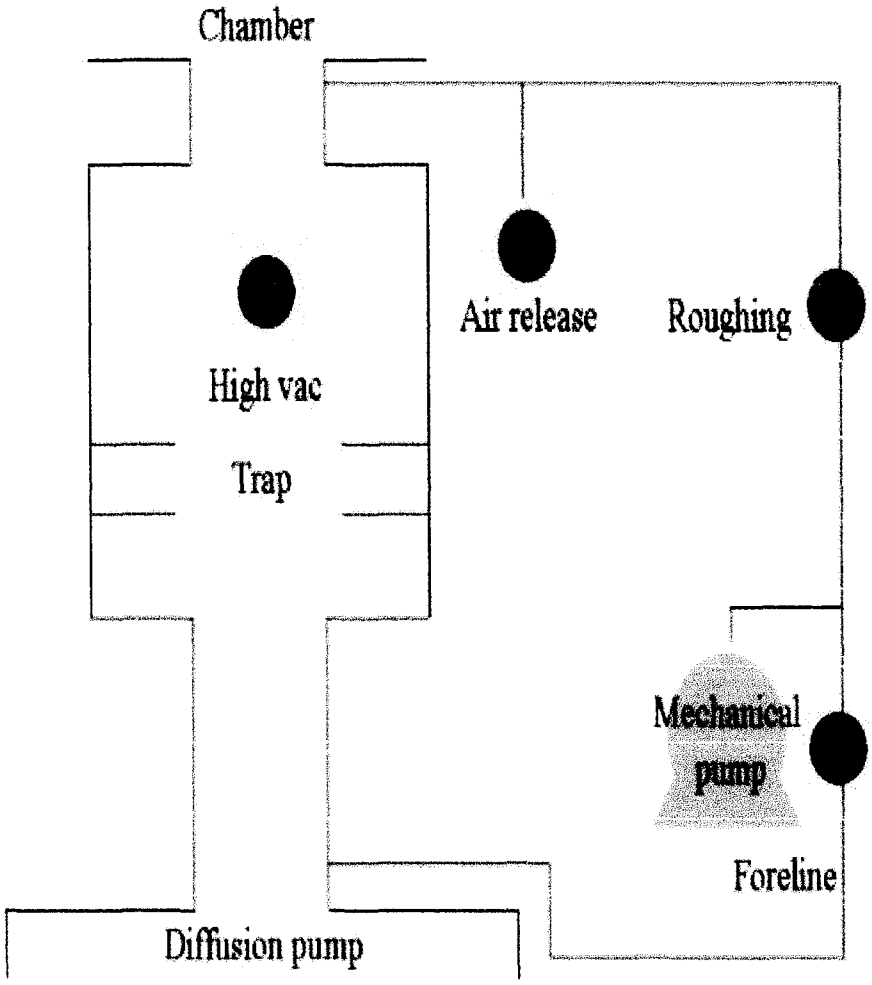
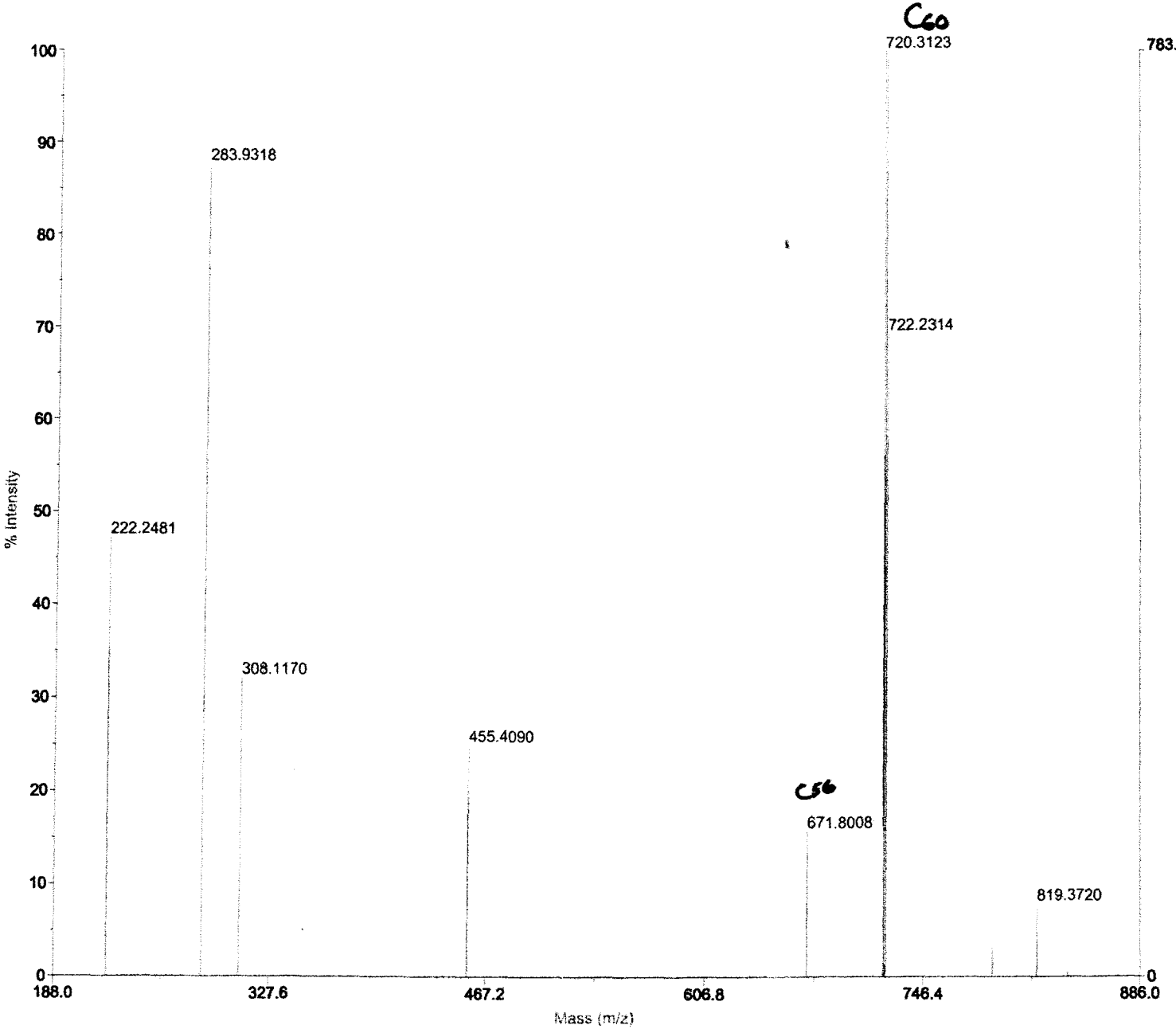


Figure 3. Vacuum Ionization Pump



Spectra 1

Voyager Spec #1[BP = 720.3, 783]



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Polarity:	~~negative~~ positive
Acquisition control:	Manual
Accelerating voltage:	20000 V
Grid voltage:	74%
Mirror voltage ratio:	1.12
Guide wire 0:	0%
Extraction delay time:	200 nsec
Acquisition mass range:	10 -- 1000 Da
Number of laser shots:	50/spectrum
Laser intensity:	1151
Laser Rep Rate:	20.0 Hz
Calibration type:	Default
Calibration matrix:	2,5-Dihydroxybenzoic a
Low mass gate:	Off
Timed ion selector:	Off
Digitizer start time:	3.284
Bin size:	0.5 nsec
Number of data points:	56810
Vertical scale 0:	50 mV
Vertical offset:	-2.5%
Input bandwidth 0:	500 MHz
Sample well:	32
Plate ID:	E
Serial number:	6263
Instrument name:	Voyager-DE PRO
Plate type filename:	C:\VOYAGER\100 well
Lab name:	UT-Knoxville
Absolute x-position:	8765.77
Absolute y-position:	32826.7
Relative x-position:	2098.27
Relative y-posititon:	759.157
Shots in spectrum:	50
Source pressure:	9.93e-008
Mirror pressure:	1.338e-008
TC2 pressure:	0.0019
TIS gate width:	8
TIS flight length:	687

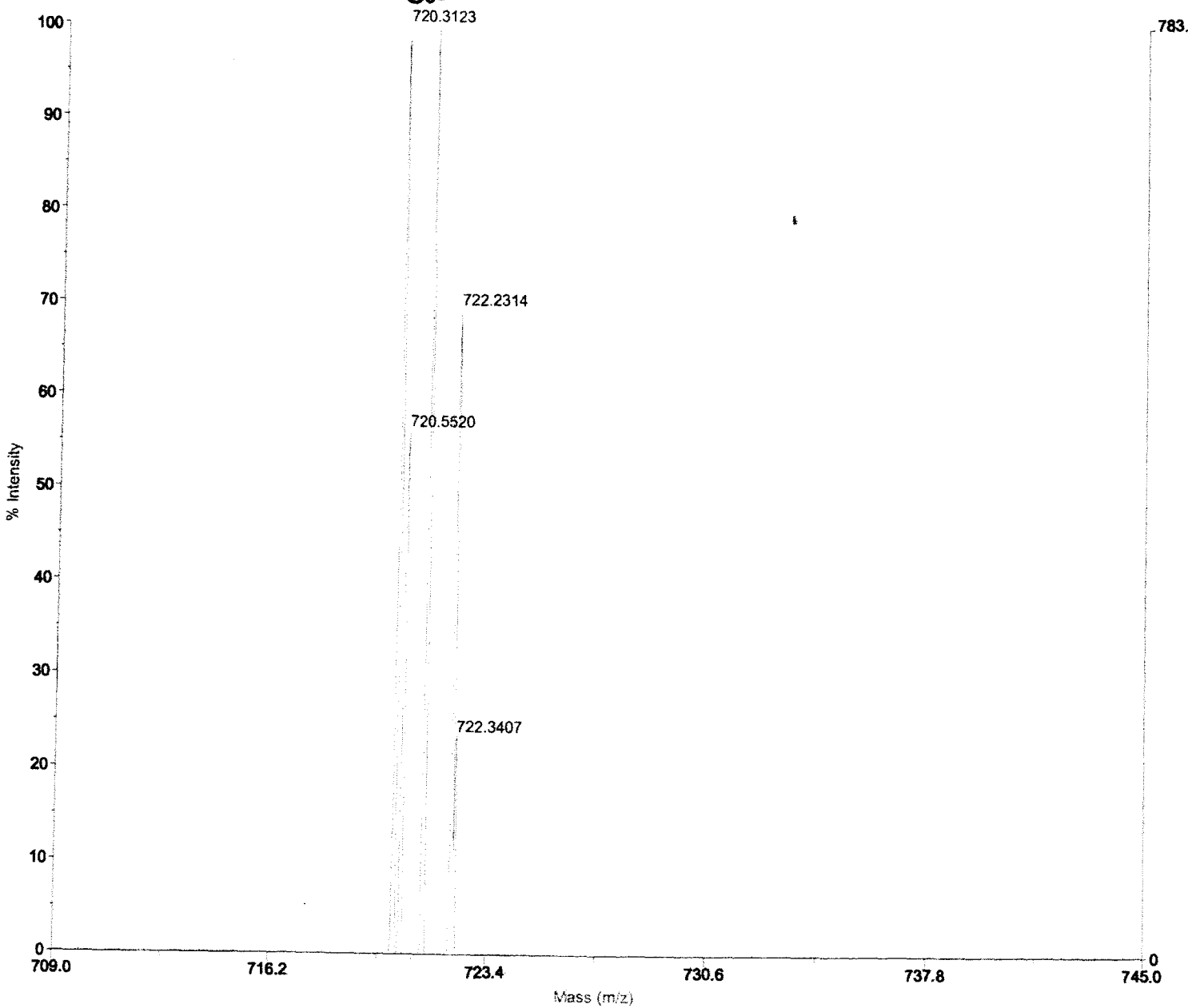
Acquired: 15:05:00, October 31, 2003
danielle's first run in positive ion
A:\c60-2_0001.dat

10/27/03

Printed: 10:08, November 0

Voyager Spec #1[BP = 720.3, 783]

C60



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Calibration matrix:	2,5-Dihydroxybenzoic ac
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Timed ion selector:	Off
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Number of data points:	56810
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Vertical offset:	-2.5%
Input bandwidth 0:	500 MHz
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Serial number:	6263
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Lab name:	UT-Knoxville
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Absolute y-position:	32826.7
Relative x-position:	2098.27
Relative y-posititon:	759.157
Shots in spectrum:	50
Source pressure:	9.93e-008
Mirror pressure:	1.338e-008
TC2 pressure:	0.0019
TIS gate width:	8
TIS flight length:	687

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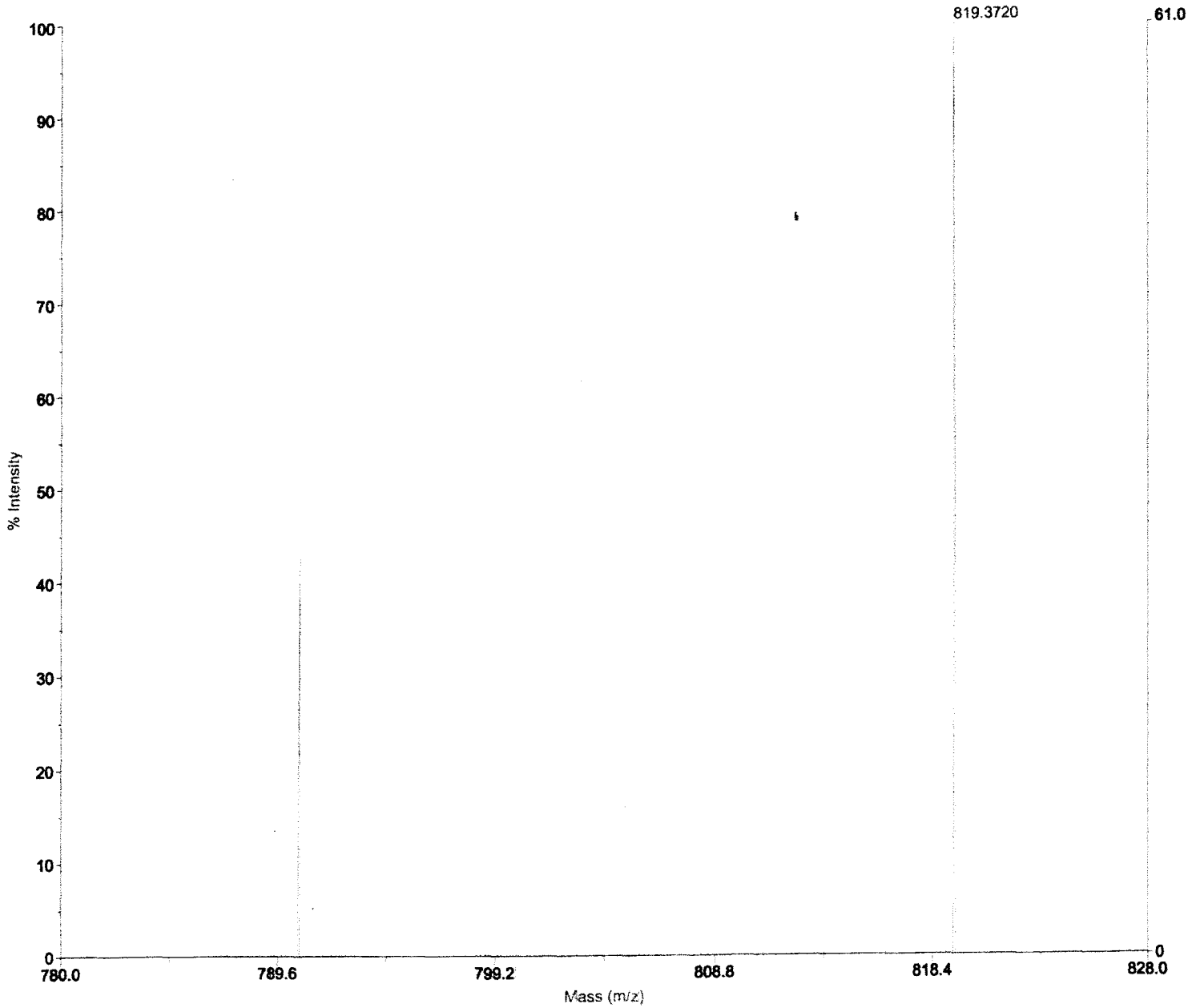
10/27/03

Printed: 10:25, November 03

Voyager Spec #1[BP = 720.3, 783]



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Absolute y-position:	32826.7
Relative x-position:	2098.27
Relative y-posititon:	759.157
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Source pressure:	9.93e-008
Mirror pressure:	1.338e-008
TC2 pressure:	0.0019
TIS gate width:	8
TIS flight length:	687

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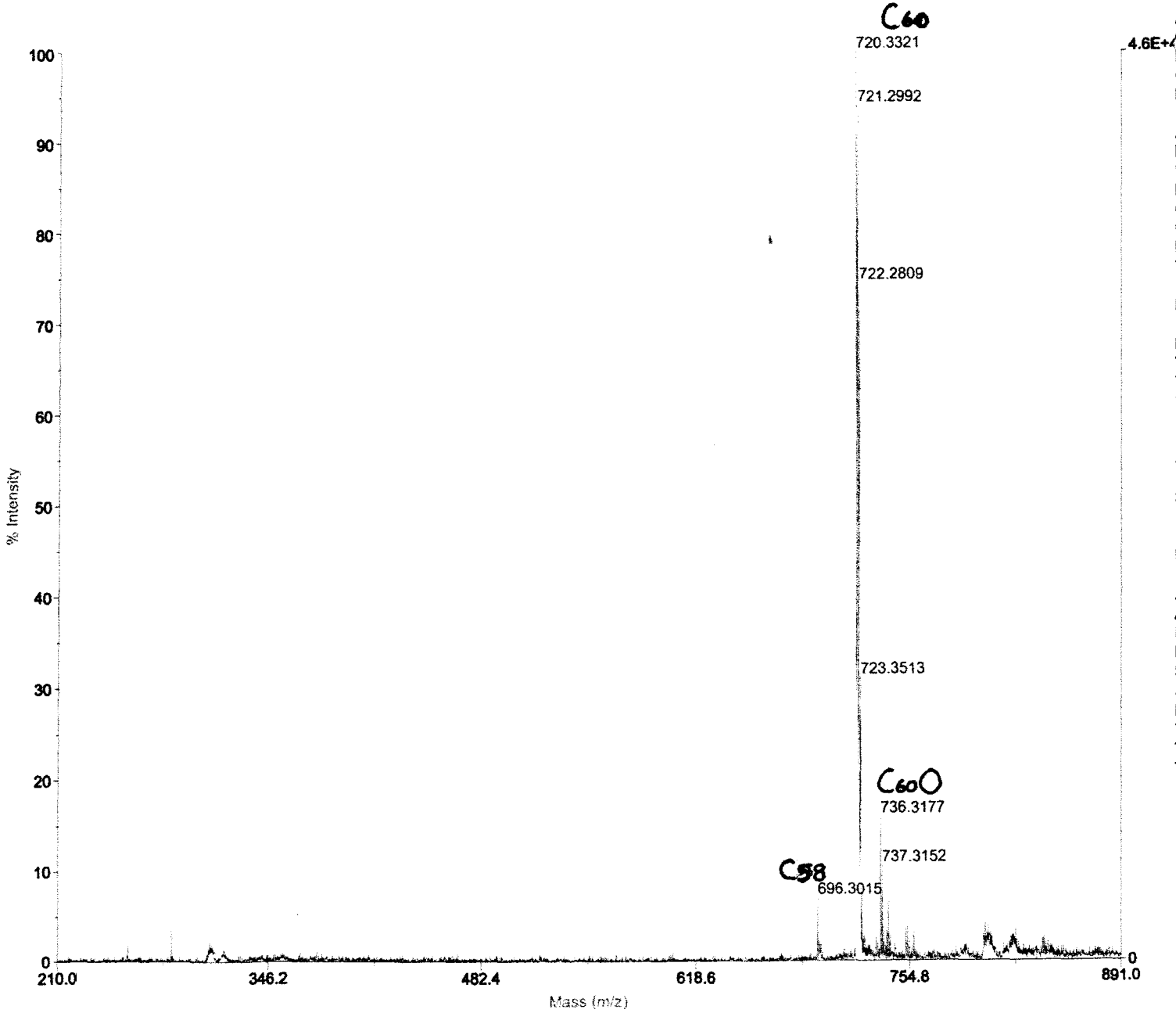
10/27/03

Printed: 10:25, November 03

Spectra 2

Voyager Spec #1[BP = 720.3, 45991]



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Acquisition mass range:	10 – 2000 Da
Number of laser shots:	100/spectrum
Laser intensity:	1569
Laser Rep Rate:	20.0 Hz
Calibration type:	Default
Calibration matrix:	2,5-Dihydroxybenzoic a
Low mass gate:	Off
Timed ion selector:	Off
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Serial number:	6263
Instrument name:	Voyager-DE PRO
Plate type filename:	C:\VOYAGER\100 well
Lab name:	UT-Knoxville
Absolute x-position:	9136.93
Absolute y-position:	32803.2
Relative x-position:	2469.43
Relative y-posititon:	735.75
Shots in spectrum:	200
Source pressure:	1.381e-007
Mirror pressure:	1.471e-008
TC2 pressure:	0.002237
TIS gate width:	8
TIS flight length:	687

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10/27/03

Printed: 10:09, November 0

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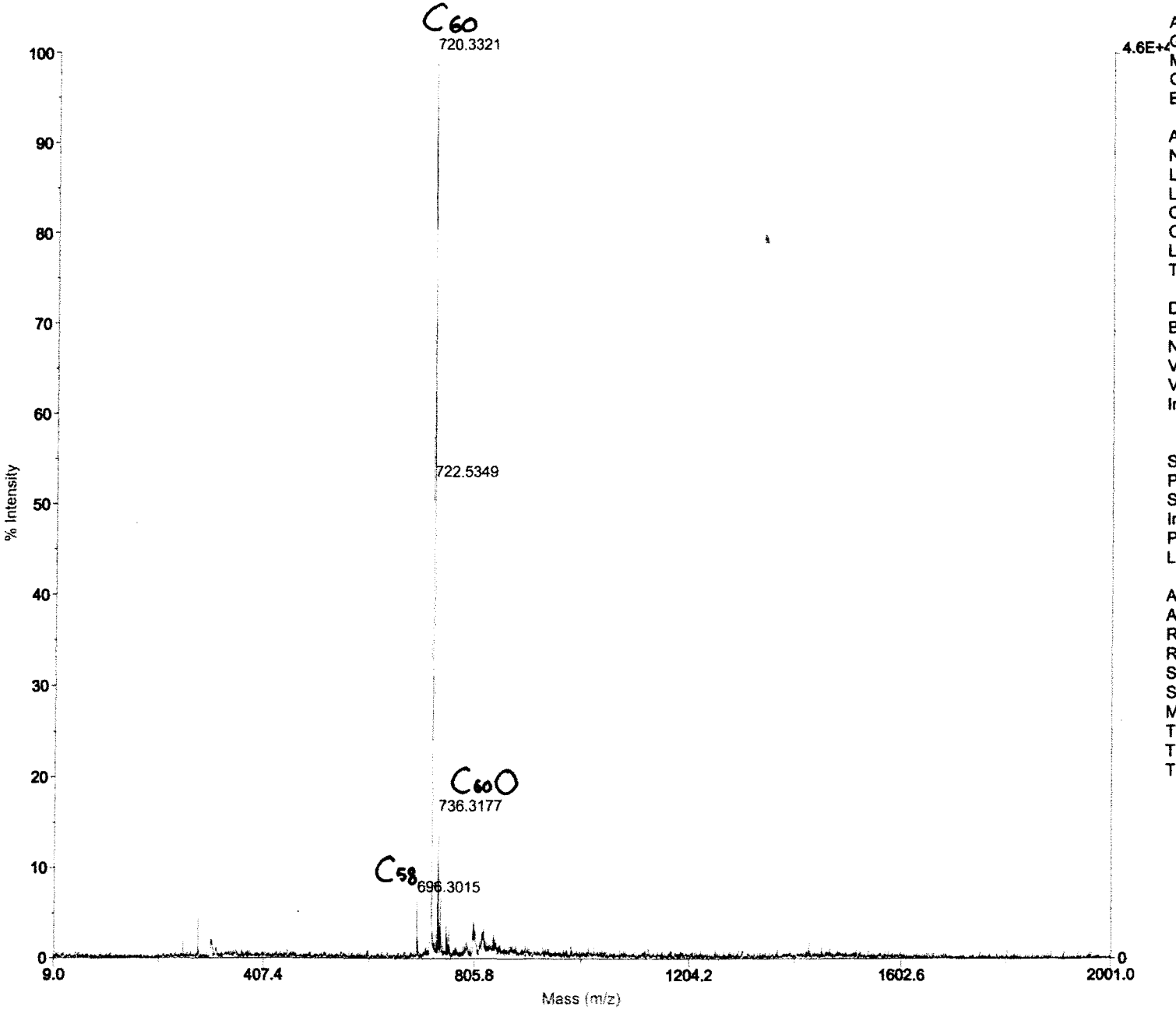

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Serial number:	6263
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Plate type filename:	C:\VOYAGER\100 well p
Lab name:	UT-Knoxville
Absolute x-position:	9136.93
Absolute y-position:	32803.2
Relative x-position:	2469.43
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10/27/03

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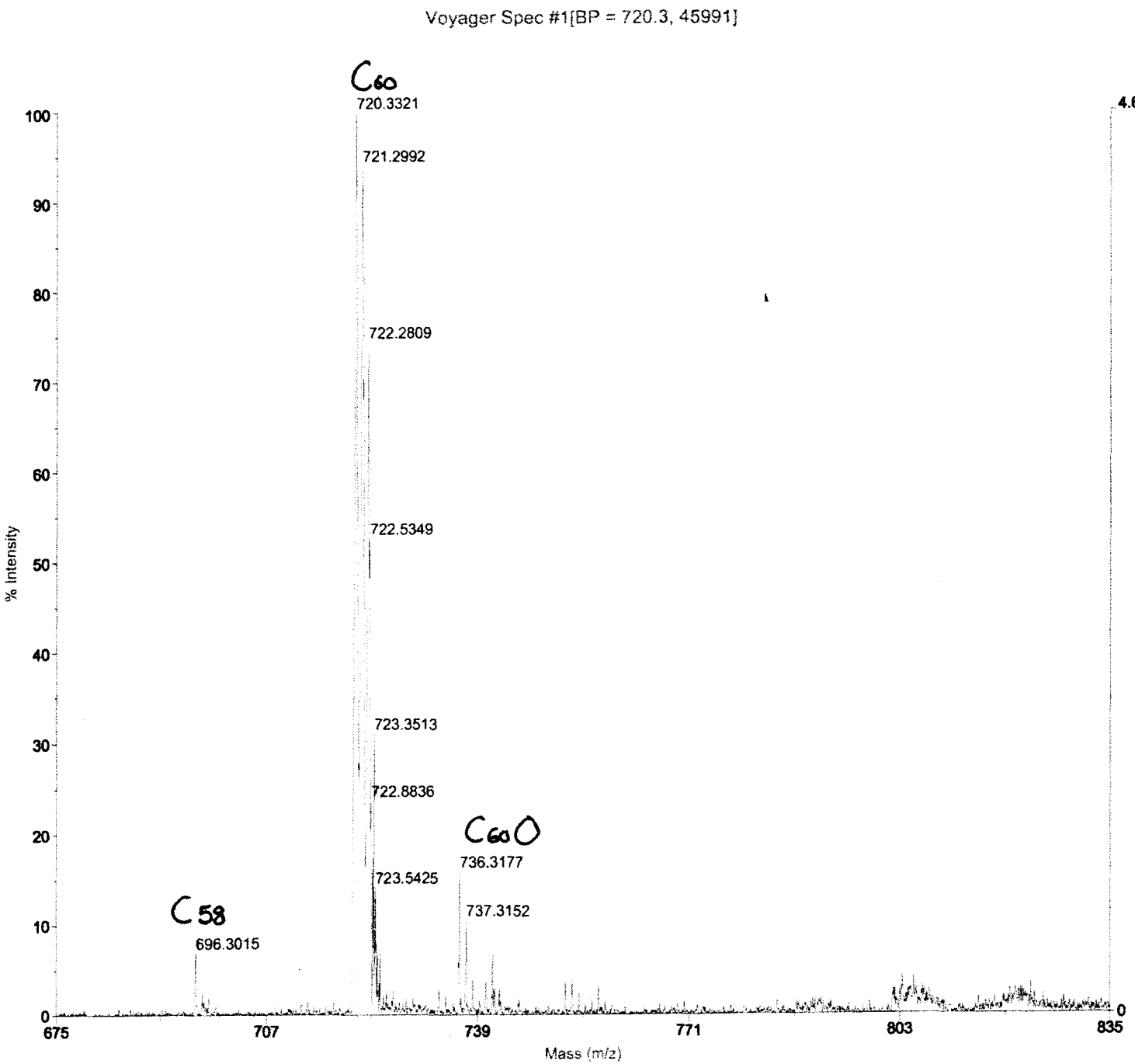

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Guide wire 0:	0%
Extraction delay time:	200 nsec
Acquisition mass range:	10 -- 2000 Da
Number of laser shots:	100/spectrum
Laser intensity:	1569
Laser Rep Rate:	20.0 Hz
Calibration type:	Default
Calibration matrix:	2,5-Dihydroxybenzoic ac
Low mass gate:	Off
Timed ion selector:	Off
Digitizer start time:	3.284
Bin size:	0.5 nsec
Number of data points:	82965
Vertical scale 0:	50 mV
Vertical offset:	-2.5%
Input bandwidth 0:	500 MHz
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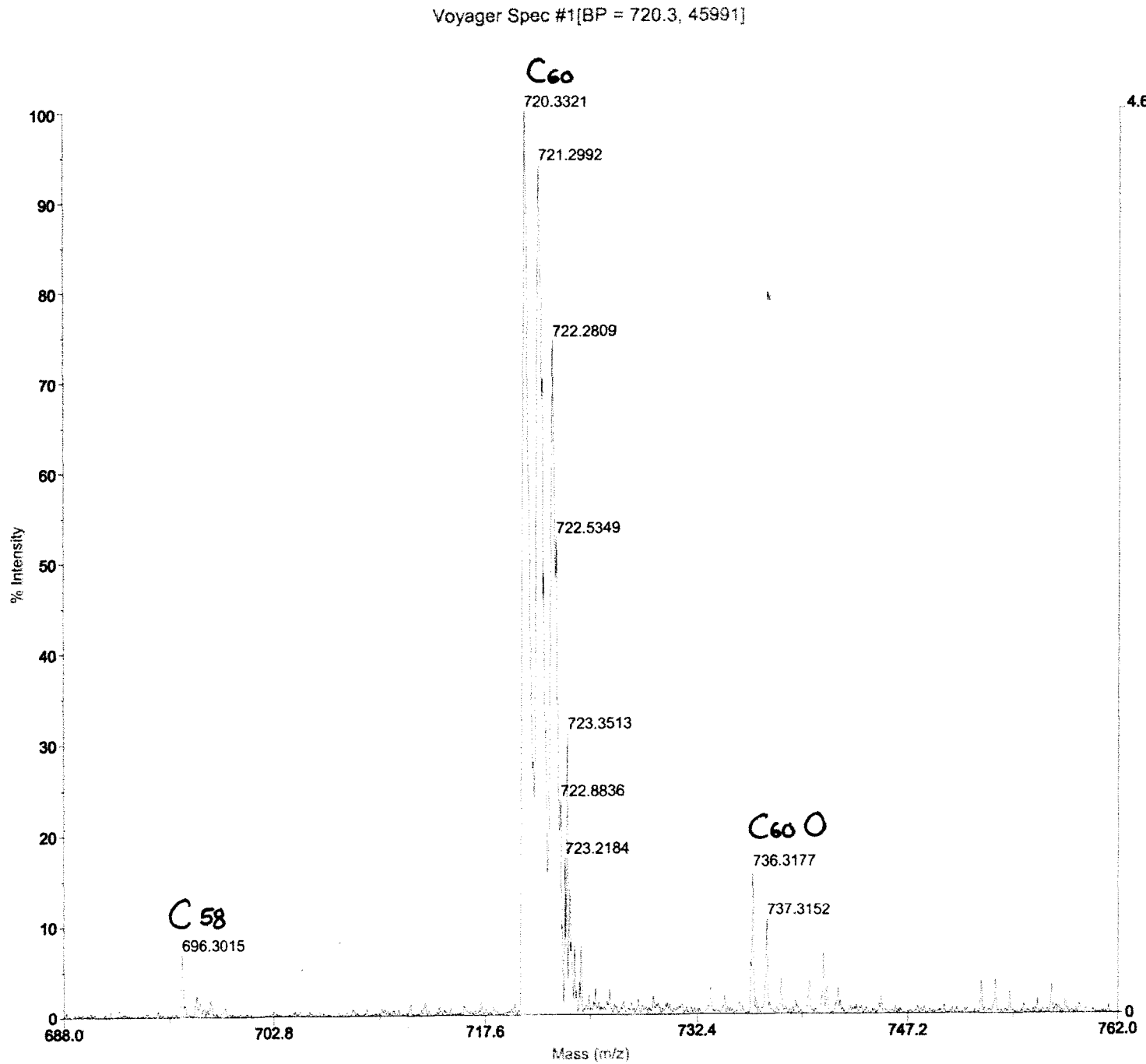
Plate ID:	E
Serial number:	6263
Instrument name:	Voyager-DE PRO
Plate type filename:	C:\VOYAGER\100 well p
Lab name:	UT-Knoxville
Absolute x-position:	9136.93
Absolute y-position:	32803.2
Relative x-position:	2469.43
Relative y-posititon:	735.75
Shots in spectrum:	200
Source pressure:	1.381e-007
Mirror pressure:	1.471e-008
TC2 pressure:	0.002237
TIS gate width:	8
TIS flight length:	687

Acquired: 14:37:00, October 31, 2003
danielle's first run in negative ion
A:\c60-1_0001.dat

10/27/03

Printed: 10:12, November 0



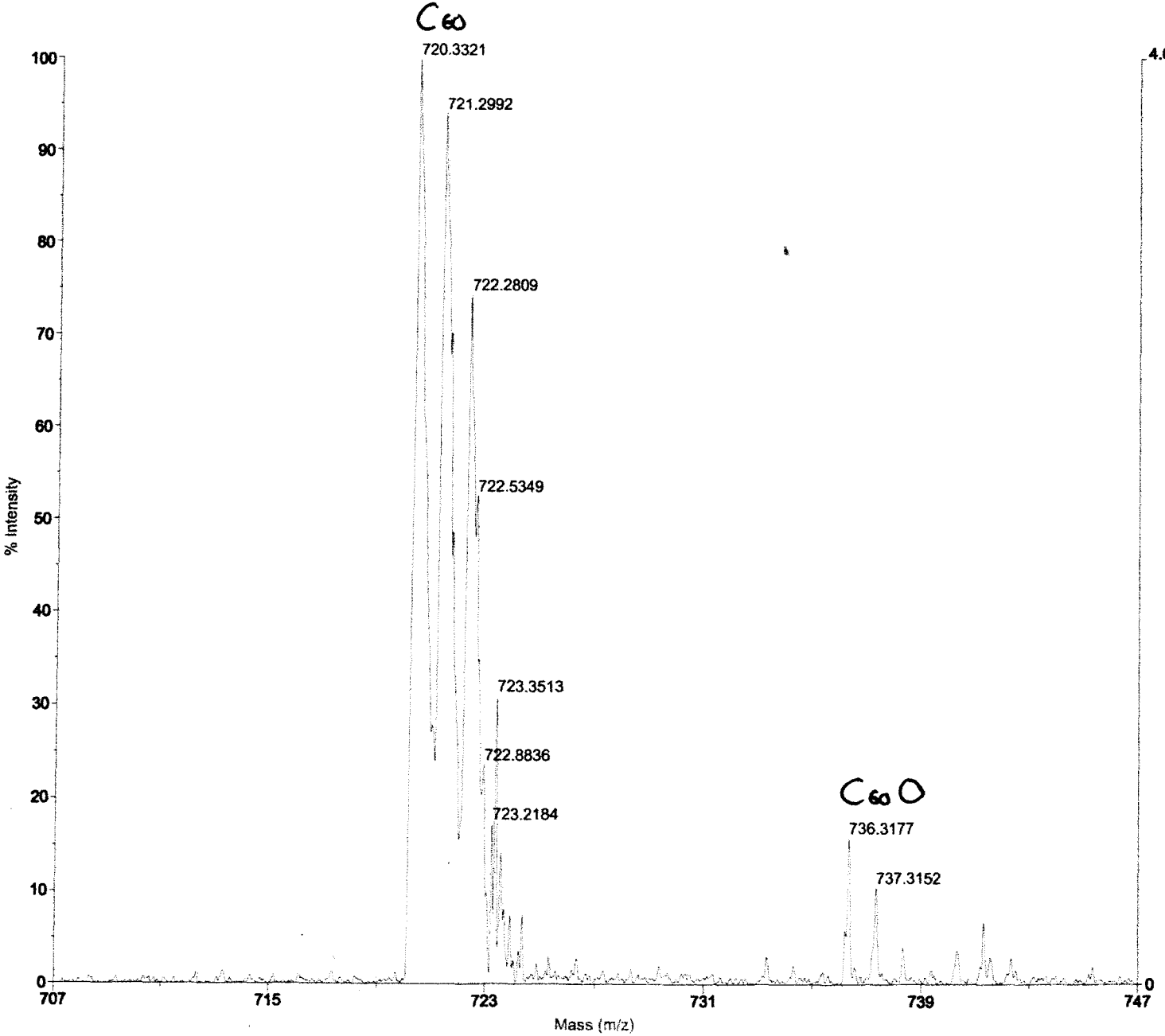
Mode of operation:	Reflector
Extraction mode:	Delayed
Polarity:	Negative
Acquisition control:	Manual
Accelerating voltage:	20000 V
Grid voltage:	74%
Mirror voltage ratio:	1.12
Guide wire 0:	0%
Extraction delay time:	200 nsec
Acquisition mass range:	10 -- 2000 Da
Number of laser shots:	100/spectrum
Laser intensity:	1569
Laser Rep Rate:	20.0 Hz
Calibration type:	Default
Calibration matrix:	2,5-Dihydroxybenzoic ε
Low mass gate:	Off
Timed ion selector:	Off
Digitizer start time:	3.284
Bin size:	0.5 nsec
Number of data points:	82965
Vertical scale 0:	50 mV
Vertical offset:	-2.5%
Input bandwidth 0:	500 MHz
Sample well:	32
Plate ID:	E
Serial number:	6263
Instrument name:	Voyager-DE PRO
Plate type filename:	C:\VOYAGER\100 well
Lab name:	UT-Knoxville
Absolute x-position:	9136.93
Absolute y-position:	32803.2
Relative x-position:	2469.43
Relative y-posititon:	735.75
Shots in spectrum:	200
Source pressure:	1.381e-007
Mirror pressure:	1.471e-008
TC2 pressure:	0.002237
TIS gate width:	8
TIS flight length:	687

Acquired: 14:37:00, October 31, 2003
danielle's first run in negative ion
A:\c60-1_0001.dat

10/27/03

Printed: 10:18, November 0

Voyager Spec #1[BP = 720.3, 45991]



Mode of operation:	Reflector
Extraction mode:	Delayed
Polarity:	Negative
Acquisition control:	Manual
Accelerating voltage:	20000 V
Grid voltage:	74%
Mirror voltage ratio:	1.12
Guide wire 0:	0%
Extraction delay time:	200 nsec
Acquisition mass range:	10 -- 2000 Da
Number of laser shots:	100/spectrum
Laser intensity:	1569
Laser Rep Rate:	20.0 Hz
Calibration type:	Default
Calibration matrix:	2,5-Dihydroxybenzoic a
Low mass gate:	Off
Timed ion selector:	Off
Digitizer start time:	3.284
Bin size:	0.5 nsec
Number of data points:	82965
Vertical scale 0:	50 mV
Vertical offset:	-2.5%
Input bandwidth 0:	500 MHz
Sample well:	32
Plate ID:	E
Serial number:	6263
Instrument name:	Voyager-DE PRO
Plate type filename:	C:\VOYAGER\100 well
Lab name:	UT-Knoxville
Absolute x-position:	9136.93
Absolute y-position:	32803.2
Relative x-position:	2469.43
Relative y-posititon:	735.75
Shots in spectrum:	200
Source pressure:	1.381e-007
Mirror pressure:	1.471e-008
TC2 pressure:	0.002237
TIS gate width:	8
TIS flight length:	687

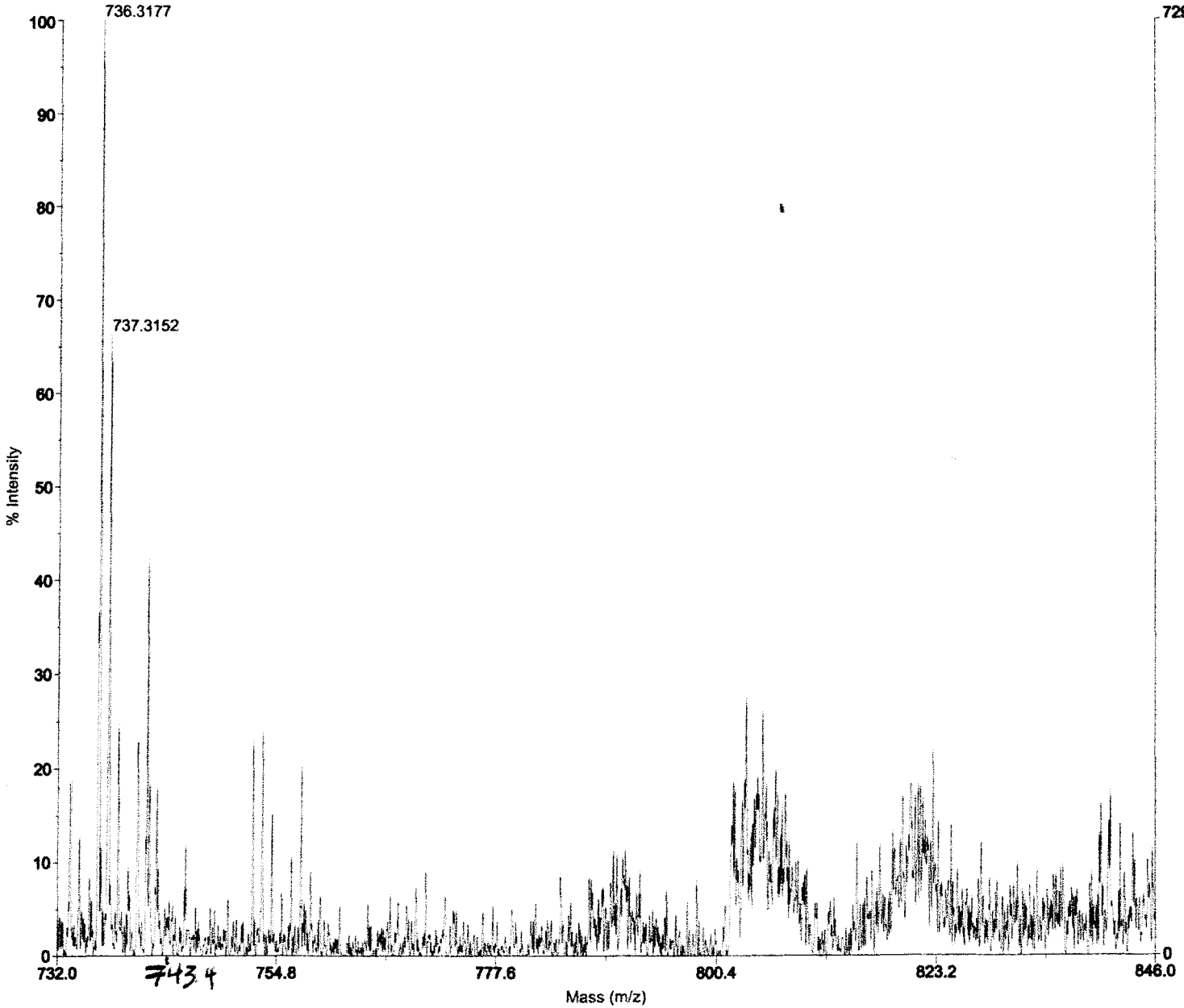
Acquired: 14:37:00, October 31, 2003
danielle's first run in negative ion
A:\c60-1_0001.dat

10/27/03

Printed: 10:12, November 0

Voyager Spec #1[BP = 720.3, 45991]

C60



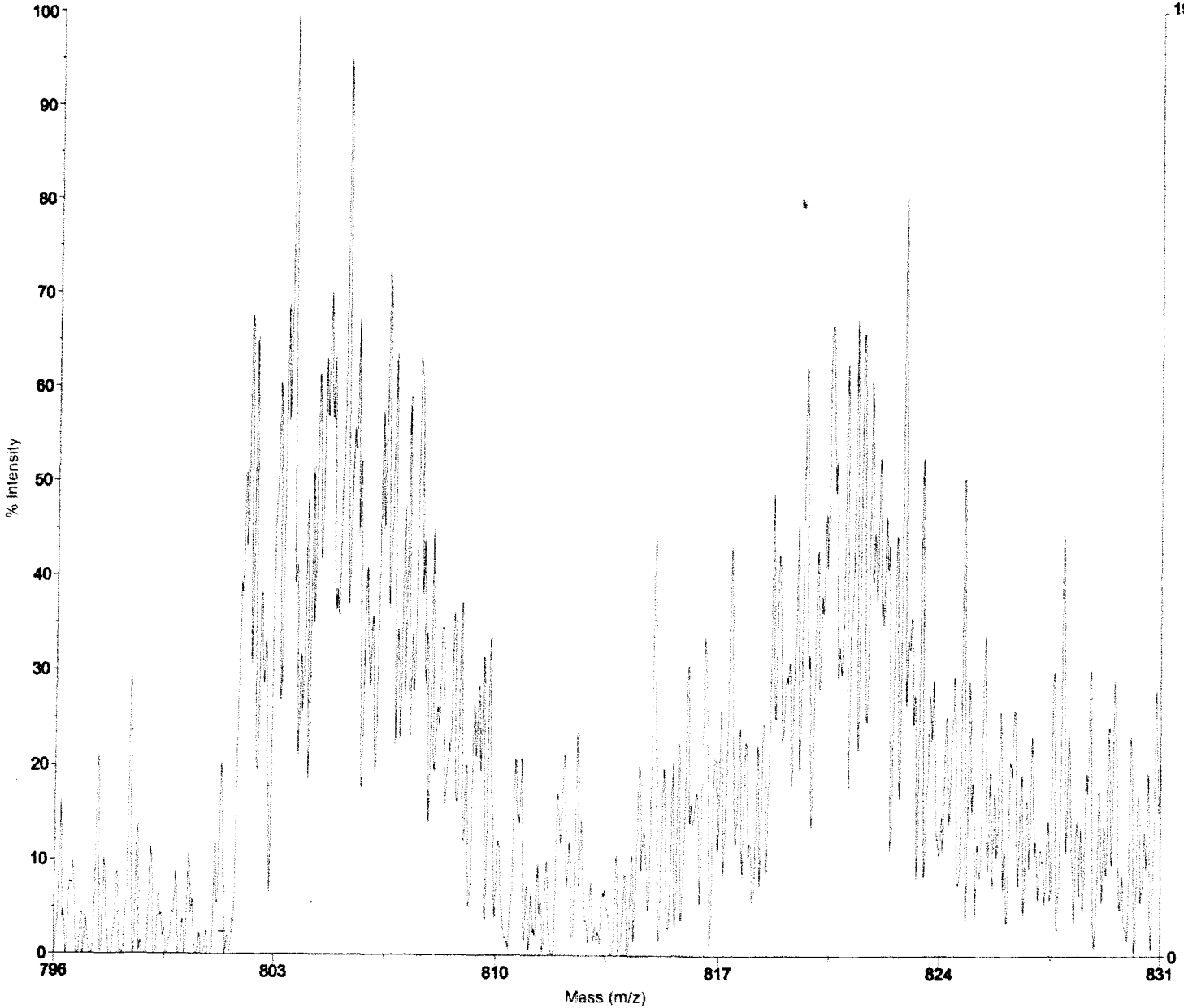
Mode of operation:	Reflector
Extraction mode:	Delayed
Polarity:	Negative
Acquisition control:	Manual
Accelerating voltage:	20000 V
Grid voltage:	74%
Mirror voltage ratio:	1.12
Guide wire 0:	0%
Extraction delay time:	200 nsec
Acquisition mass range:	10 – 2000 Da
Number of laser shots:	100/spectrum
Laser intensity:	1569
Laser Rep Rate:	20.0 Hz
Calibration type:	Default
Calibration matrix:	2,5-Dihydroxybenzoic
Low mass gate:	Off
Timed ion selector:	Off
Digitizer start time:	3.284
Bin size:	0.5 nsec
Number of data points:	82965
Vertical scale 0:	50 mV
Vertical offset:	-2.5%
Input bandwidth 0:	500 MHz
Sample well:	32
Plate ID:	E
Serial number:	6263
Instrument name:	Voyager-DE PRO
Plate type filename:	C:\VOYAGER\100 wel
Lab name:	UT-Knoxville
Absolute x-position:	9136.93
Absolute y-position:	32803.2
Relative x-position:	2469.43
Relative y-posititon:	735.75
Shots in spectrum:	200
Source pressure:	1.381e-007
Mirror pressure:	1.471e-008
TC2 pressure:	0.002237
TIS gate width:	8
TIS flight length:	687

Acquired: 14:37:00, October 31, 2003
danielle's first run in negative ion
A:\c60-1_0001.dat

10/27/03

Printed: 10:19, November (

Voyager Spec #1[BP = 720.3, 45991]



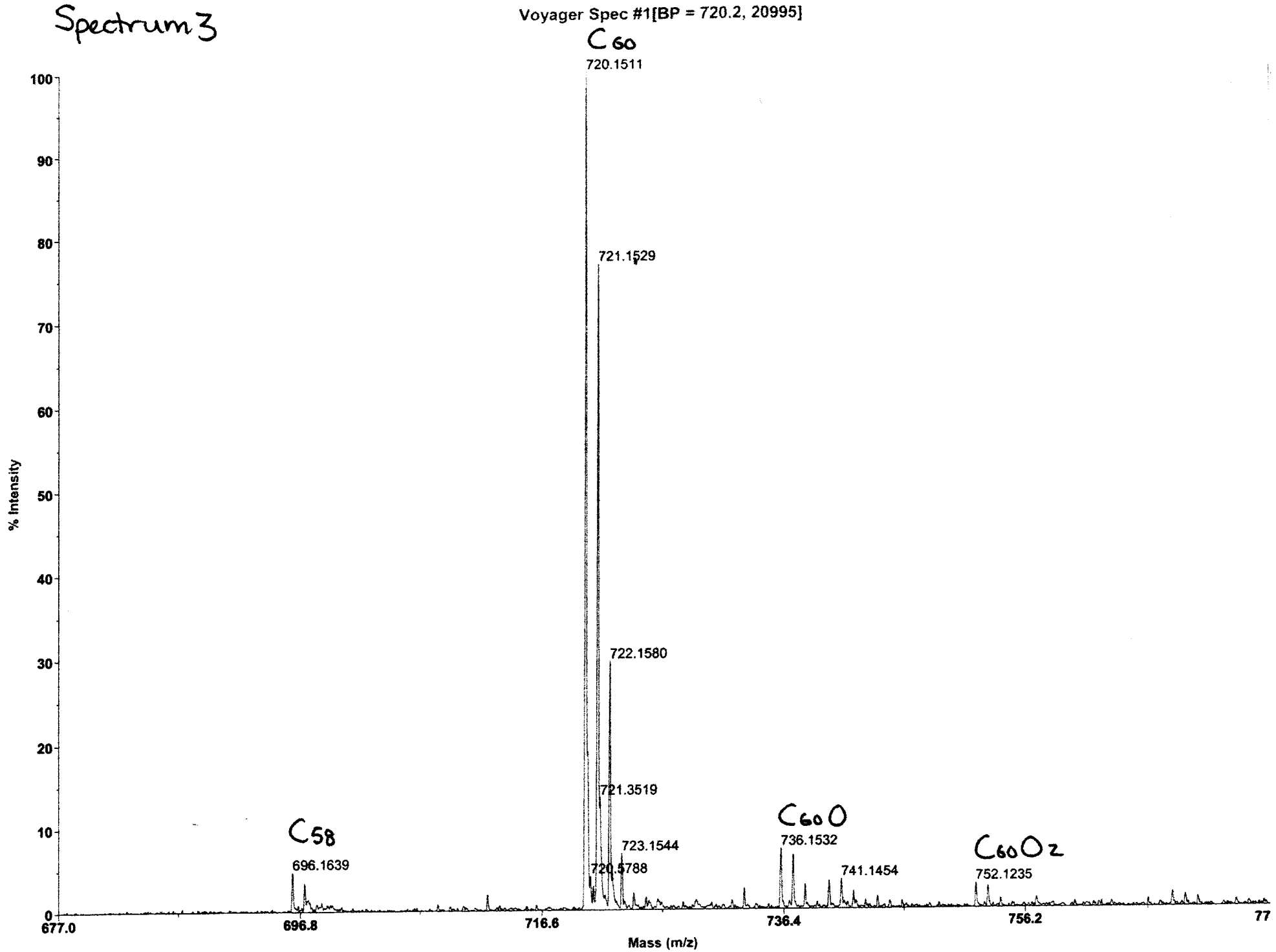
Mode of operation:	Reflector
Extraction mode:	Delayed
Polarity:	Negative
Acquisition control:	Manual
Accelerating voltage:	20000 V
Grid voltage:	74%
Mirror voltage ratio:	1.12
Guide wire 0:	0%
Extraction delay time:	200 nsec
Acquisition mass range:	10 -- 2000 Da
Number of laser shots:	100/spectrum
Laser intensity:	1569
Laser Rep Rate:	20.0 Hz
Calibration type:	Default
Calibration matrix:	2,5-Dihydroxybenzoic a
Low mass gate:	Off
Timed ion selector:	Off
Digitizer start time:	3.284
Bin size:	0.5 nsec
Number of data points:	82965
Vertical scale 0:	50 mV
Vertical offset:	-2.5%
Input bandwidth 0:	500 MHz
Sample well:	32
Plate ID:	E
Serial number:	6263
Instrument name:	Voyager-DE PRO
Plate type filename:	C:\VOYAGER\100 well p
Lab name:	UT-Knoxville
Absolute x-position:	9136.93
Absolute y-position:	32803.2
Relative x-position:	2469.43
Relative y-posititon:	735.75
Shots in spectrum:	200
Source pressure:	1.381e-007
Mirror pressure:	1.471e-008
TC2 pressure:	0.002237
TIS gate width:	8
TIS flight length:	687

Acquired: 14:37:00, October 31, 2003
danielle's first run in negative ion
A:\c60-1_0001.dat

10/27/03

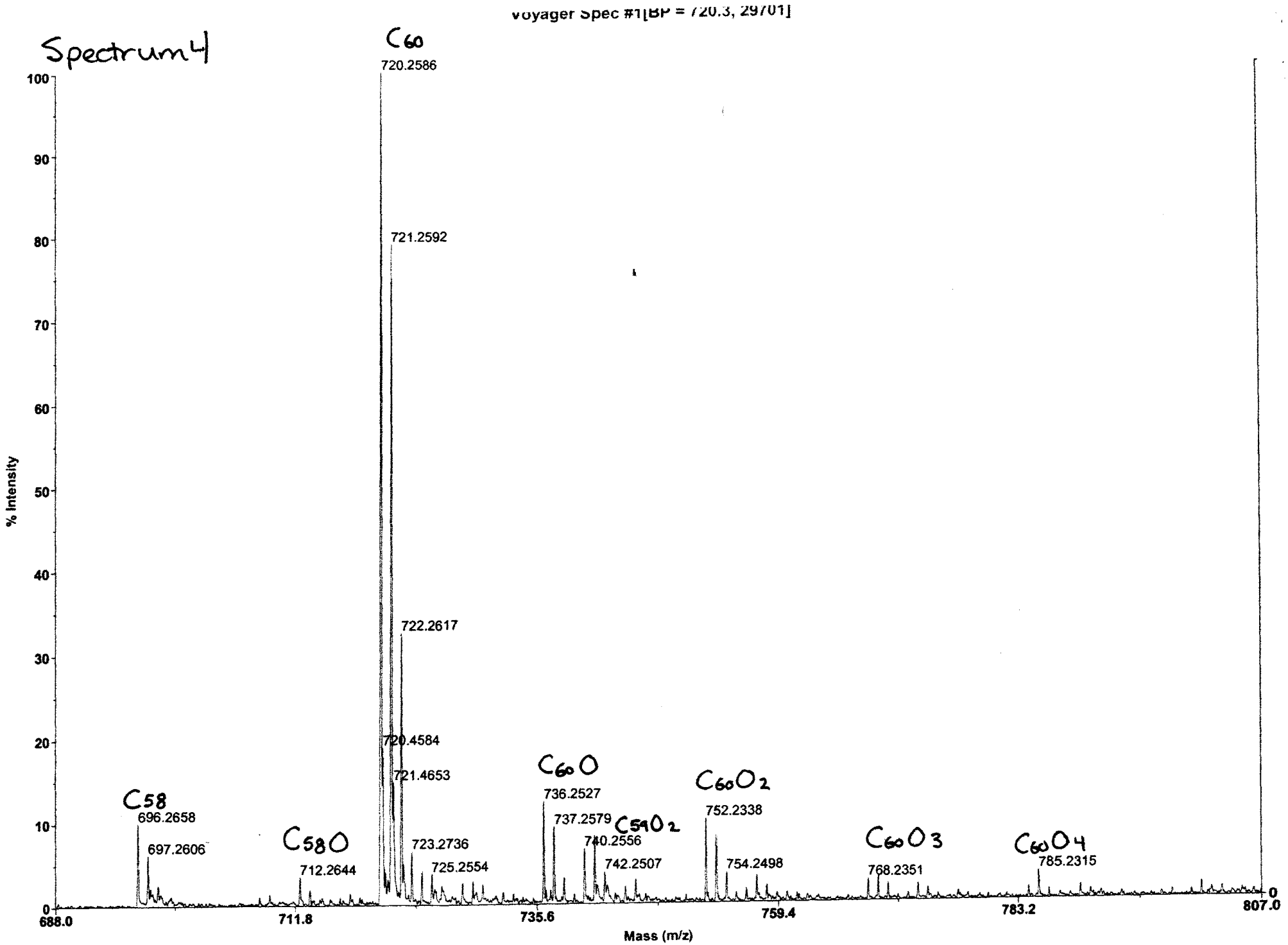
Printed: 10:15, November 03

Spectrum 3



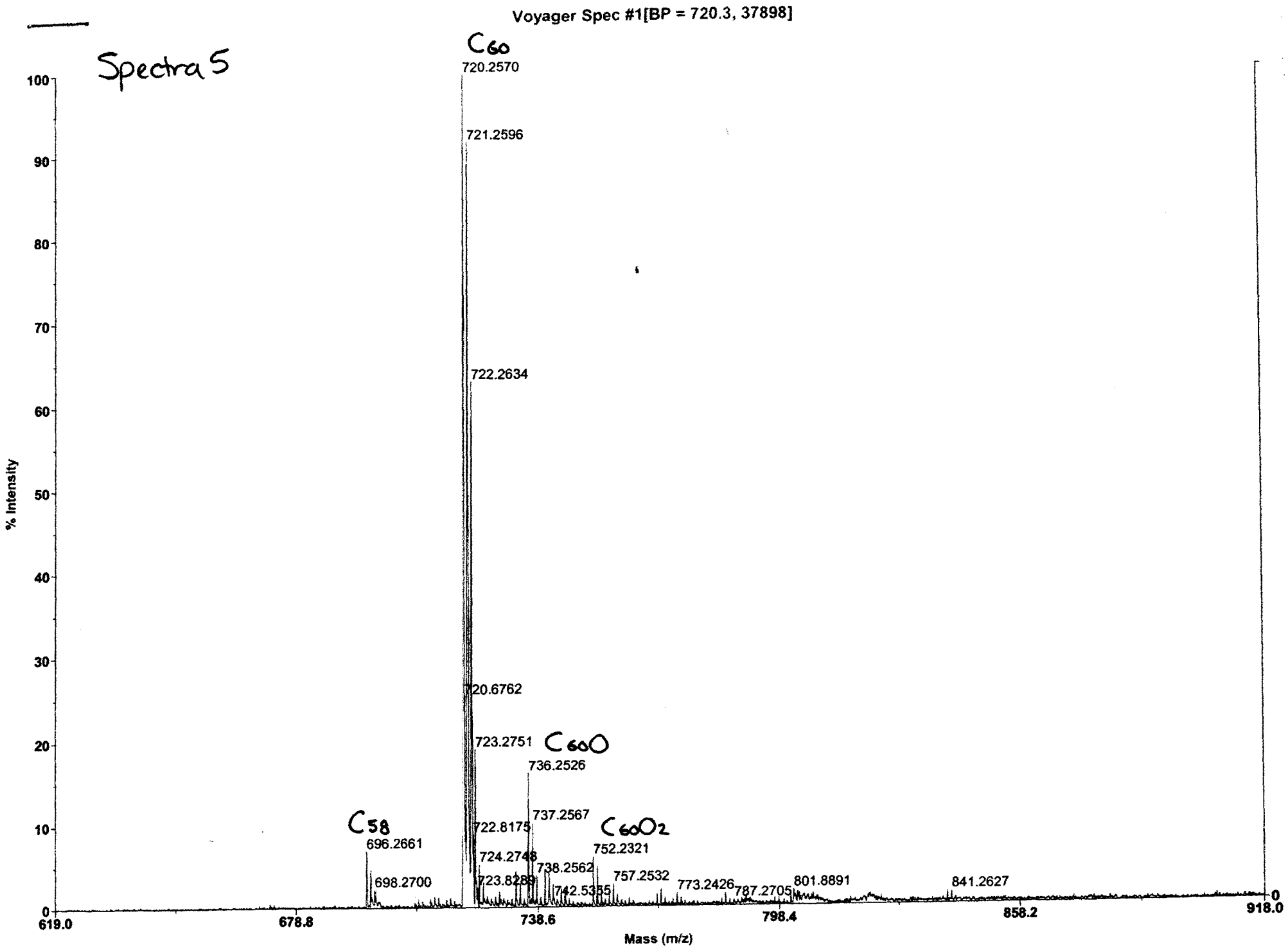
800 shots
D:\...\NaC0A2_0001.dat
Acquired: 13:53:00, December 01, 2003

11/7/03



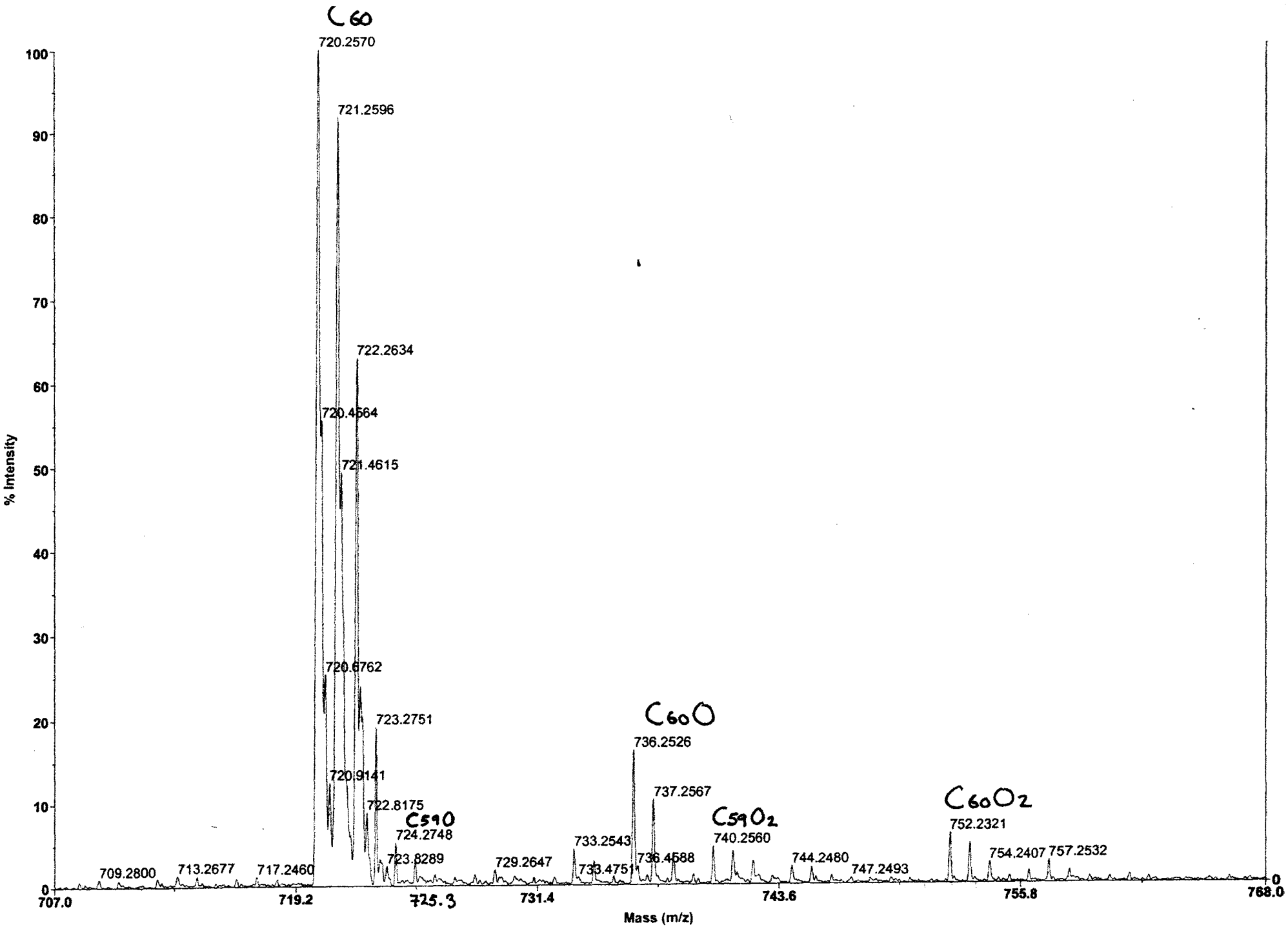
100 shots
D:\...\NaC0B_0001.dat
Acquired: 13:55:00, December 01, 2003

11/7/03



00 shots
:\...\NaC0C_0001.dat
cquired: 13:58:00, December 01, 2003

11/17/03



00 shots
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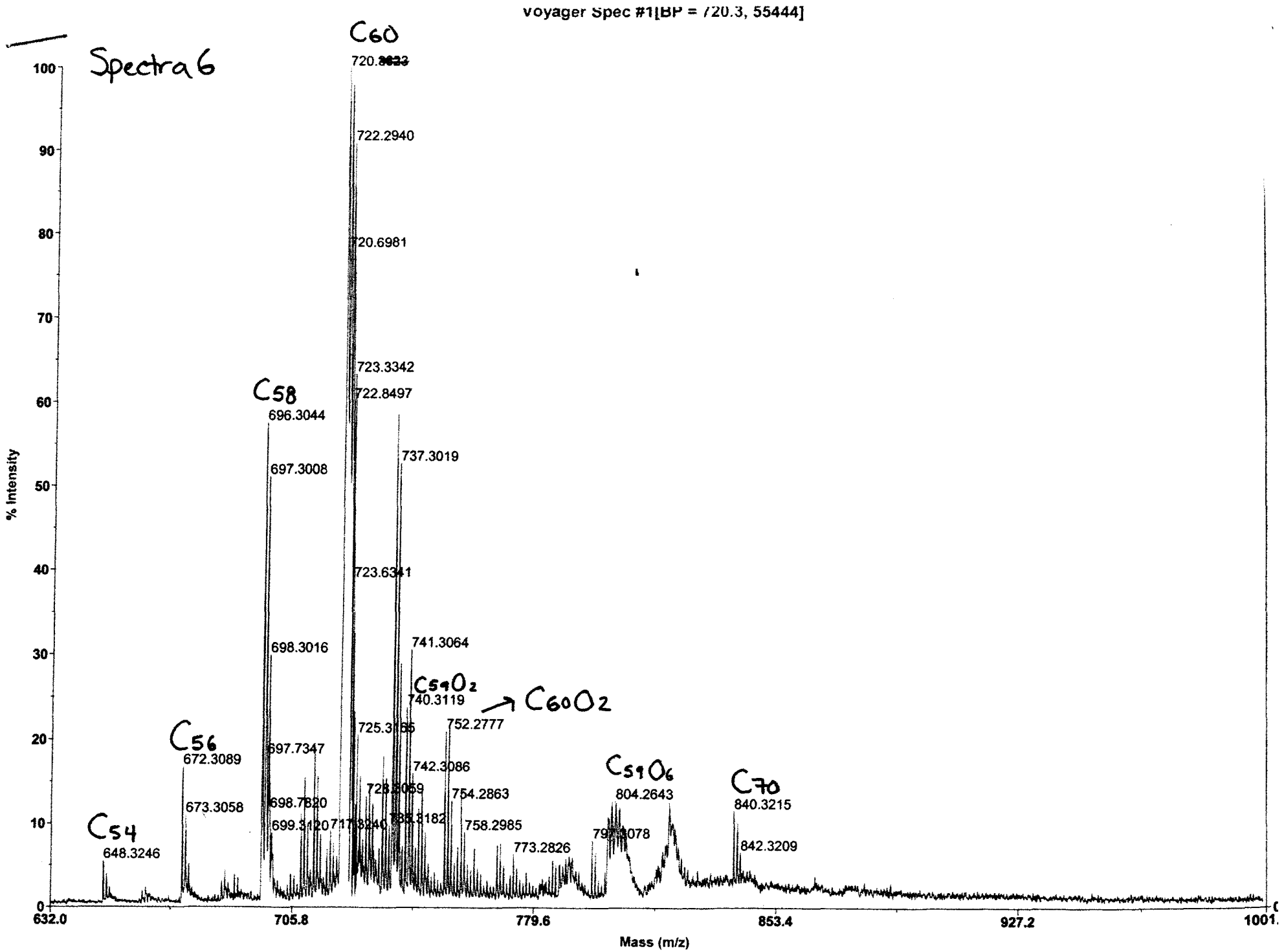
11/17/03



800 shots
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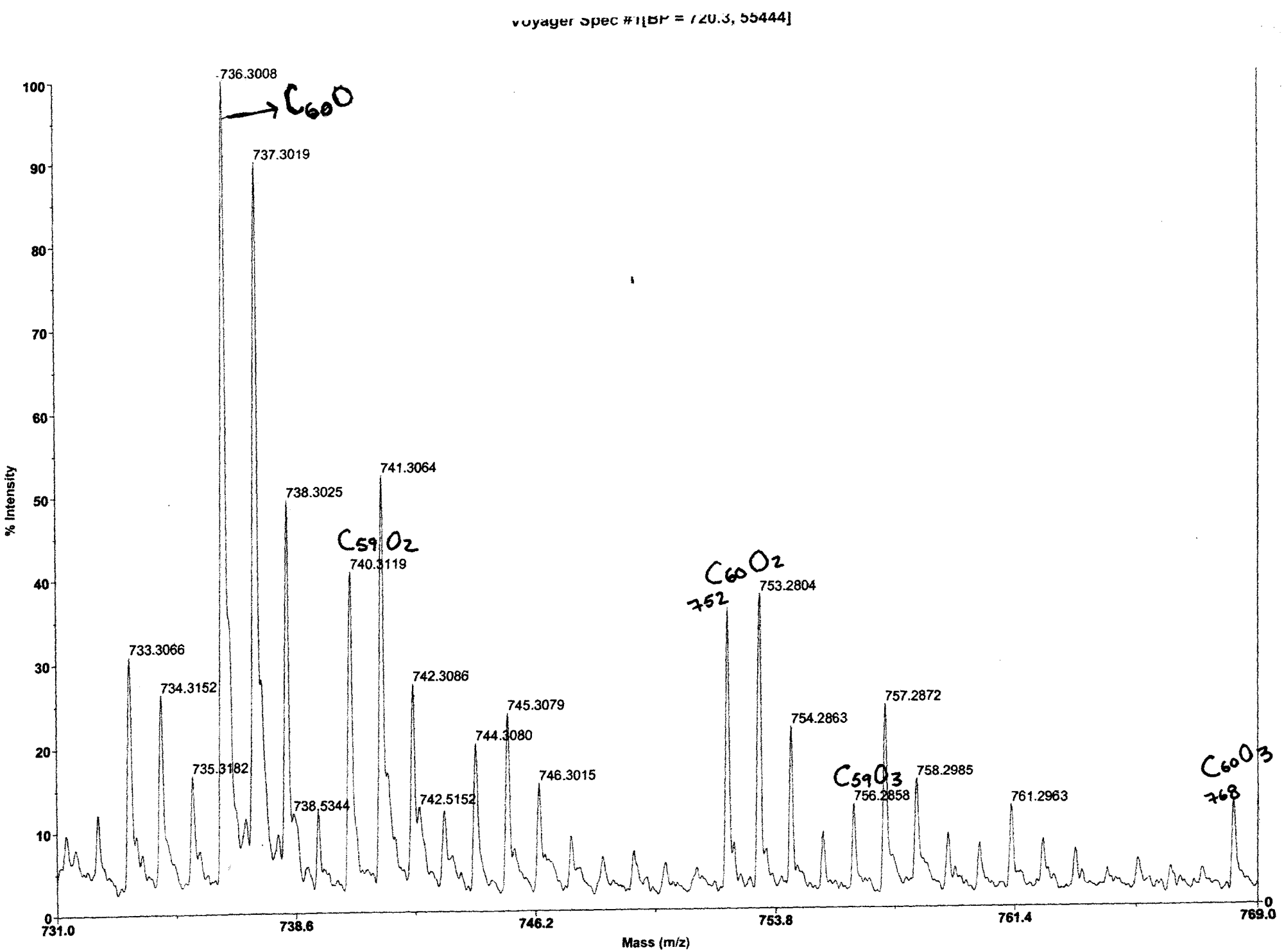
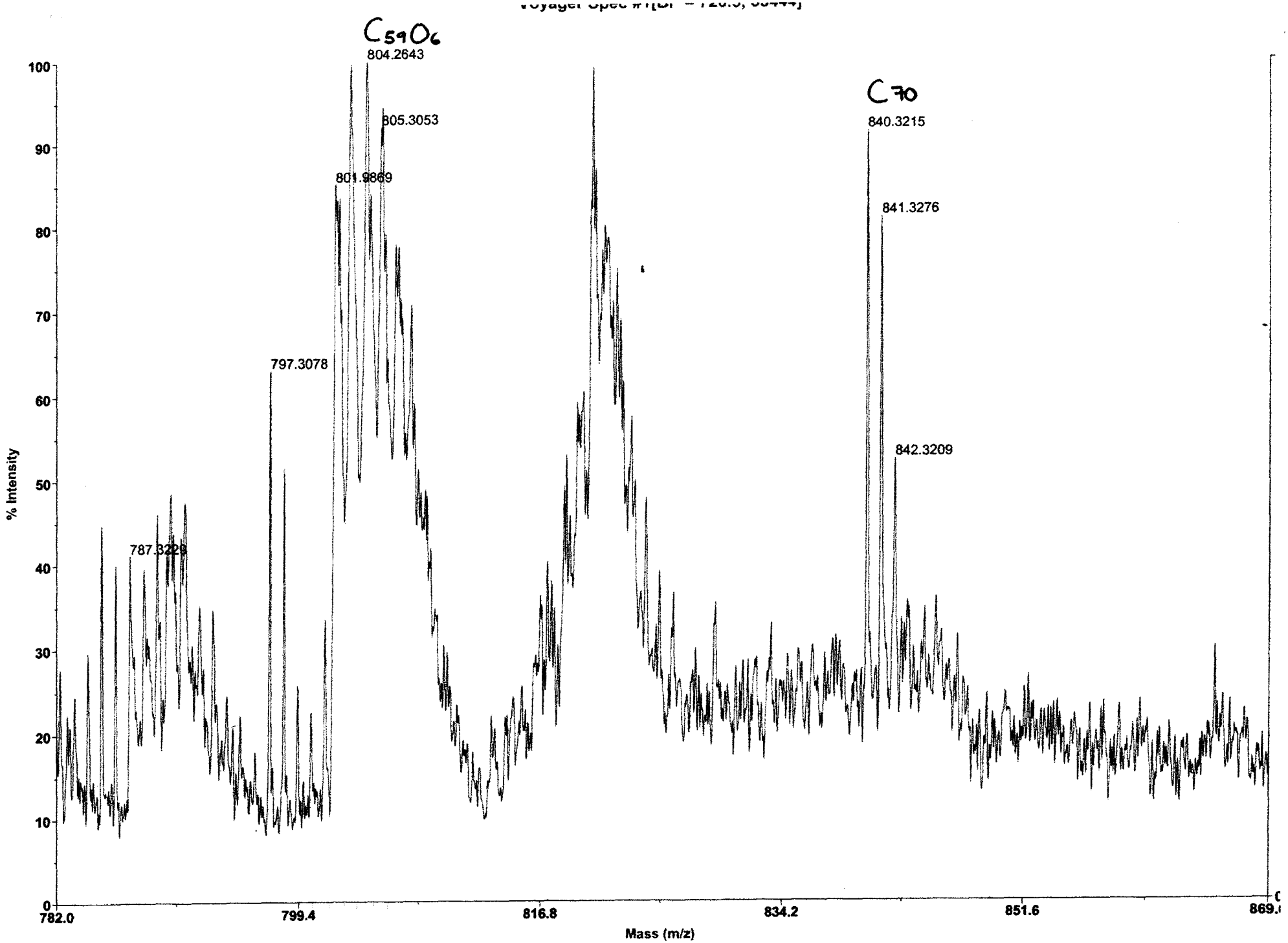
Acquired: 14:00:00, December 01, 2003

11/17/03



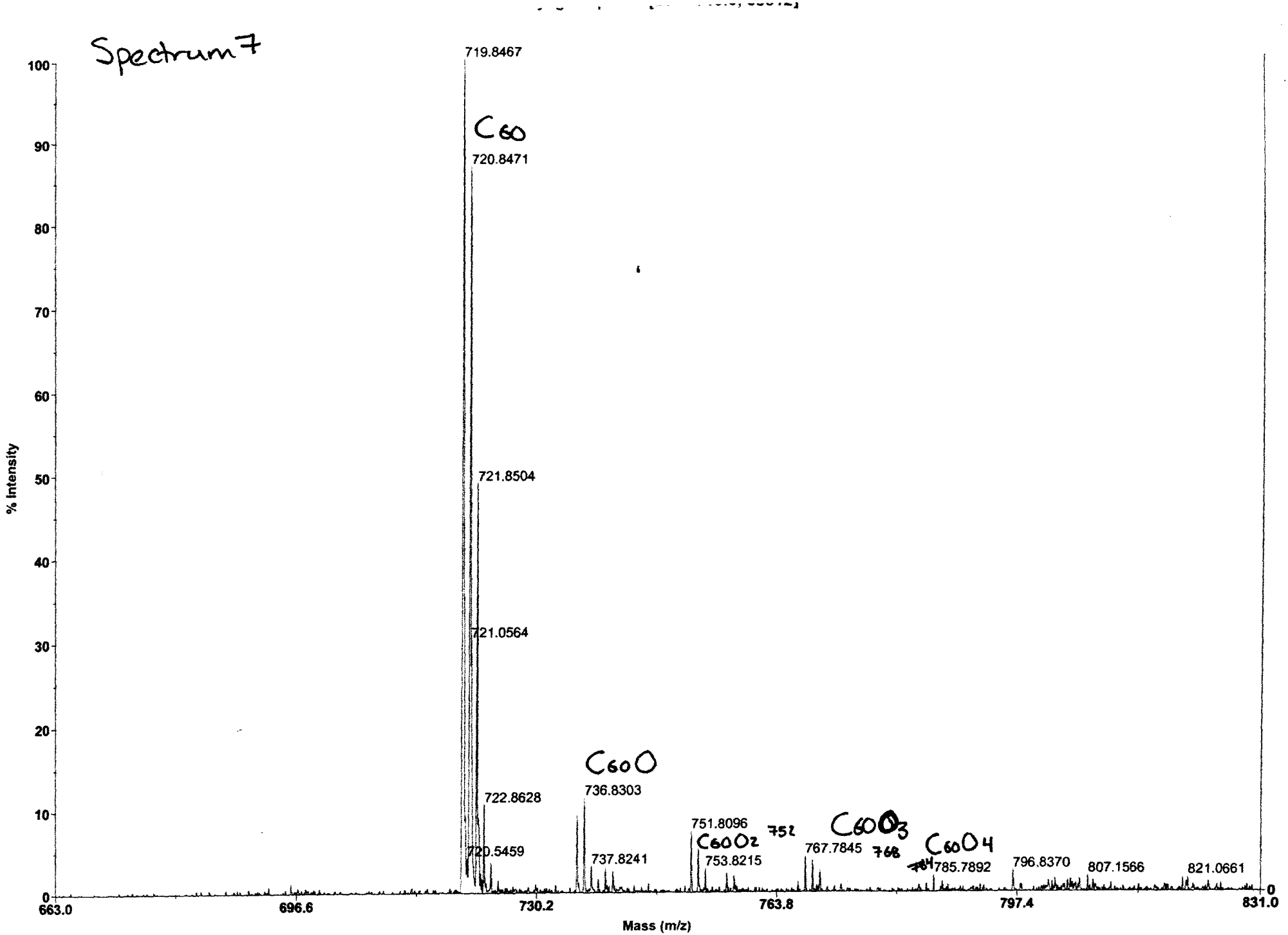
00 shots
:\...\NaC0C2_0001.dat
cquired: 14:00:00, December 01, 2003

11/17/03



800 shots
D:\...\NaC0C2_0001.dat
Acquired: 14:00:00, December 01, 2003

11/17/03



Blank
11/17/03

):\...\C60blank2_0001.dat
cquired: 13:49:00, December 01, 2003

Works Cited

1. Allen, Kim. "Endohedral" Fullerenes. 2003. 27 November 2003 <http://www.mindspring.com/~kimall/Fuller/endo.html>
2. Cientifica. Fullerenes: Technology White Papers nr.7 October 2003. 3 December 2003 <http://nanotechweb.org/nanowhitepapers/fullerenes_WP.pdf>
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