A Study of Copper(II) Oxide and Copper(II) Acetate on Multi-Walled Carbon Nanotubes by XPS

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We present the XPS survey and detailed element spectra of a copper-carbon nanotube composite synthesized in our laboratories. We compare the copper spectrum to a reference spectrum of copper(II) acetate measured under the same conditions to ascertain the chemical composition of the copper in the composite.ww

Keywords: Copper, XPS, Multi-walled carbon nanotubes

Acccession#:

Technique: XPS

Host Material: 1) CuAc 2) CuO on MWCNTs

Instrument: Kratos XPS Supra

Major Elements in Spectra: Cu, C

Minor Elements in Spectra: O, In

Published Spectra: 9

Spectra in Electronic Record: 15

Spectral Category: comparison

INTRODUCTION

The development of copper-carbon nanotube composites is of interest for application in ultra-conductive copper wire[1]. Ultra-conductive copper wire consists of a copper species and a nanocarbon, such as graphene or carbon nanotubes[2]. The copper-carbon composites are also of interest as electrocatalysts for the electrocatalytic reduction of carbon dioxide to higher value products such as methane and ethylene[3]. A number of synthetic procedures are available and have been used for manufacturing such composites[4-7]. Depending on the procedure the copper can be chemically bound to the carbon nanotubes or just associated with the carbon nanotubes. The composites can be characterized using solid-state techniques such as scanning electron microscopy, x-ray diffraction and x-ray photoelectron spectroscopy (XPS). For the analysis of copper-carbon nanotube composites it is particularly important to determine the copper oxidation state. In addition, the modelling of the carbon 1s signal is non-trivial as it consists of sp2, sp3, adventitious and oxidized carbon, along with plasmon signals. We have characterized a commercial sample of copper(II) acetate as a reference sample. (XPS spectra of copper(II) acetate are uncommon in the literature to the best of our knowledge.) We have also measured the XPS spectra of a synthesized copper-carbon composite[8]. We have ascertained the chemical composition and oxidation state of the copper in the composite using our reference spectra.[9] Following literature precedent we have modelled the carbon 1s signal using a mixed Donjiach-Sunjik Sum Gaussian Lorentzian (30) fitting[10]. We have found this model to be particularly effective. In this study, particular importance is given to the analysis of the C 1s and Cu 2p signals.

Host Material: CuAc

- **CAS Registry #:** 142-71-2

Host Material Characteristics: homogeneous; solid; polycrystalline; conductor; composite; Other

Chemical Name: Copper(II) acetate

Source: Sigma-Aldrich

Host Composition: C, Cu, H, O

Form: Polycrystalline composite

Structure: $Cu(CH_3OO)_2$

History & Significance: $Cu(Ac)_2$ powder was used as received.

As Received Condition: The as-received sample was a blue crystalline solid.

Analyzed Region: Same as host material.

Ex Situ Preparation/Mounting: The composite was pressed onto carbon tape.

In Situ Preparation: none

Charge Control: Charge neutralizer was used.

Temp. During Analysis: 300K

Pressure During Analysis: 4 x 10^{-6} Pa

Pre-analysis Beam Exposure: 0 s.

SPECIMEN DESCRIPTION (ACCESSION #00000)

Host Material: CuO/MWCNT

CAS Registry #: unknown

Host Material Characteristics: homogeneous; solid; polycrystalline; conductor; composite; Other

Chemical Name: Copper(II) oxide on multi-walled carbon nanotubes.

[a)]Electronic mail: author@institution.edu

Source: Cu(II)Ac purchased from Sigma Aldrich and used as received. MWCNTs synthesized at Rice University, Texas, USA and purified before use[11].

Host Composition: CuO on MWCNTs

Form: Amorphous composite

Structure: $CuOC_x$

History & Significance: 6 mg of powdered CuAc were added to a vial containing 10 mg of MWCNTs. 6 ml of distilled water was added and the mixture sonicated for 15 minutes in order to disperse the copper particles amongst the MWCNTs. The water was evaporated by drying the sample in the oven at 80 °C for 4 hours. The sample was then heated in the microwave for 3 x 1 minutes at 1000 W to decompose the copper(II) acetate to copper(II) oxide. The product obtained was a black powder.

As Received Condition: The as-prepared sample was a black solid.

Analyzed Region: Same as host material.

Ex Situ Preparation/Mounting: The material was pressed onto indium foil.

In Situ Preparation: none

Charge Control: Charge neutralizer was used

Temp. During Analysis: 300 K

Pressure During Analysis: 4×10^{-6} Pa

Pre-analysis Beam Exposure: 0 s.

As Received Condition:Pre-analysis Beam Exposure:s

INSTRUMENT DESCRIPTION

Manufacturer and Model: Kratos Axis Supra

Analyzer Type: spherical sector

Detector: multichannel resistive plate

Number of Detector Elements: 3 MCP, 128 channel DLD

INSTRUMENT PARAMETERS COMMON TO ALL SPECTRA

■*Spectrometer*

Analyzer Mode: constant pass energy

Throughput ($T=E^N$): N=0

Excitation Source Window: not specified

Excitation Source: Al Ka monochromatic

Source Energy: 1486.6 eV

Source Strength: 225 W

Source Beam Size: 700 μm x 300 μm

Signal Mode: multichannel direct

■*Geometry*

Incident Angle: 54.7 °

Source-to-Analyzer Angle: 54.7 °

Emission Angle: 0 °

Specimen Azimuthal Angle: N/A °

Acceptance Angle from Analyzer Axis: 0 °

Analyzer Angular Acceptance Width: 30 ° x 30 °

■*Ion Gun*

Manufacturer and Model: Kratos GCIS Minibeam 6

Energy: 10 k eV

Current: 23 mA

Current Measurement Method: biased stage

Sputtering Species: Argon 1000+ ion clusters

Spot Size (unrastered): 200 μm

Raster Size: 2000 μm x 2000 μm

Incident Angle: 40 °

Polar Angle: 0 °

Azimuthal Angle: 0 °

Comment: Sputtering was carried out on reference samples only.

DATA ANALYSIS METHOD

Energy Scale Correction: The binding energy scale was referenced to C 1s = 248.8 eV[8]

Recommended Energy Scale Shift: Spectra 5-9 have been shifted by 3.146 eV.

Peak Shape and Background Method: A Shirley background was used[12]. Peak shape was Gaussian Lorentzian product formula GL(30) for all components except the dominant C (1s) peak which was fitted as a mixture of Doniach-Sunjik DS (0.03, 0) and Sum Gaussian Lorentzian SGL (30) following the protocol set by Kalbac *et. al.*[10]

Quantitation Method: Quantification was done using component definitions with CasaXPS version 2.3.15. Sensitivity factors supplied by Kratos Analytical.

ACKNOWLEDGMENTS

Dr. James McGettrick is thanked for training JAR on the XPS instrument and for helpful discussions regarding the modelling of peaks. We would also like to thank reviewer 2 for their thorough comments on the paper, which has undoubtedly improved it. JAR and EA acknowledge funding from EPSRC project reference EP/N009525/1, DRJ and CWD acknowledge funding from the Flexis project, which is part-funded by the European Regional Development Fund (ERDF) through the Welsh Government. We would like to thank EPSRC for funding Swansea University AIM Facilities (EP/M028267/1) and the European Regional Development Fund (80708) via Welsh Government.

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SPECTRAL FEATURES TABLE

Spectrum ID #	Element/ Transition	Peak Energy (eV)	Peak Width FWHM (eV)	Peak Area (eV x cts/s)	Sensitivity Factor	Concentration (at. %)	Peak Assignment
02	C 1s	284.8	1.14	17970.12	0.278	28.27	Adventitious **C-C/C-**H
02	C 1s	285.7	1.14	1145.73	0.278	1.80	Adventitious **C-**O
02	C 1s	286.6	1.14	472.52	0.278	0.74	Adventitious **C=O**
02	C 1s	288.7	2.13	2882.22	0.278	4.53	CH_3**C**OO
03	O 1s	529.6	0.91	41263.46	0.78	23.14	Cu**O**
03	O 1s	531.1	1.30	20545.78	0.78	11.52	Cu**O**/Cu(CH_3C**OO**)$_2$
03	O 1s	531.9	1.30	9273.46	0.78	5.20	Adventitious Organics
03	O 1s	533.2	1.30	2225.00	0.78	1.25	Adventitious Organics
04	Cu $2p_{3/2}$	933.5	2.70	114896.4	5.321	9.44	**Cu**O
04	Cu $2p_{3/2}$	935.1	2.67	15249.3	5.321	1.25	**Cu**Ac
04	Cu $2p_{3/2}$	940.3	1.48	21574.2	5.321	1.77	Satellite
04	Cu $2p_{3/2}$	942.1	1.48	17964.6	5.321	1.48	Satellite
04	Cu $2p_{3/2}$	943.8	1.48	23539.8	5.321	1.93	Satellite
04	Cu $2p_{1/2}$	953.2	2.67	49866.98	5.321	4.10	**Cu**O
04	Cu $2p_{1/2}$	954.9	2.67	8754.96	5.321	0.72	**Cu**Ac
04	Cu $2p_{1/2}$	962.1	2.40	34476.98	5.321	2.83	Satellite
06	C 1s	284.4	0.59	41401.63	0.278	72.99	MWCNT
06	C 1s	284.8	0.93	4284.43	0.278	7.55	Adventitious **C**-**C**/**C**-H
06	C 1s	285.8	0.93	2211.15	0.278	3.90	Adventitious **C**-OH/**C**-O-**C**
06	C 1s	286.7	0.93	989.36	0.278	1.74	Adventitious **C**=O
06	C 1s	288.6	0.93	370.2	0.278	0.65	Cu(CH_3**C**OO)$_2$
06	C 1s	290.3	3.00	1987.22	0.278	3.50	π→ π* transitions
07	O 1s	530.2	1.30	2380.91	0.78	1.5	Cu**O**/Fe_2**O**$_3$/In_2**O**$_3$
07	O 1s	531.3	1.30	2696.75	0.78	1.69	Cu(CH_3C**OO**)$_2$
07	O 1s	532.1	1.30	3903.26	0.78	2.45	Adventitious C-**O**-C/C=**O**
07	O 1s	533.1	1.30	1650.75	0.78	1.04	Adventitious C-**O**H
07	O 1s	534.6	1.30	330.12	0.78	0.21	Chemisorbed H_2**O**
08	Cu $2p_{3/2}$	934.2	3.06	5942.50	5.321	0.55	**Cu**O
08	Cu $2p_{3/2}$	941.4	2.48	1231.98	5.321	0.11	Satellite
08	Cu $2p_{3/2}$	944.0	2.48	1588.81	5.321	0.15	Satellite
08	Cu $2p_{1/2}$	953.9	3.44	2946.87	5.321	0.27	**Cu**O
08	Cu $2p_{1/2}$	962.6	2.57	1308.17	5.321	0.12	Satellite
09	In $3d_{5/2}$	444.90	1.54	9324.94	7.265	0.63	**In** metal
09	In $3d_{5/2}$	445.8	1.54	2074.62	7.265	0.14	**In**$_2$O$_3$
09	In $3d_{3/2}$	452.4	1.54	6204.8	7.265	0.42	**In** metal
09	In $3d_{3/2}$	453.3	1.54	1380.45	7.265	0.09	**In**$_2$O$_3$

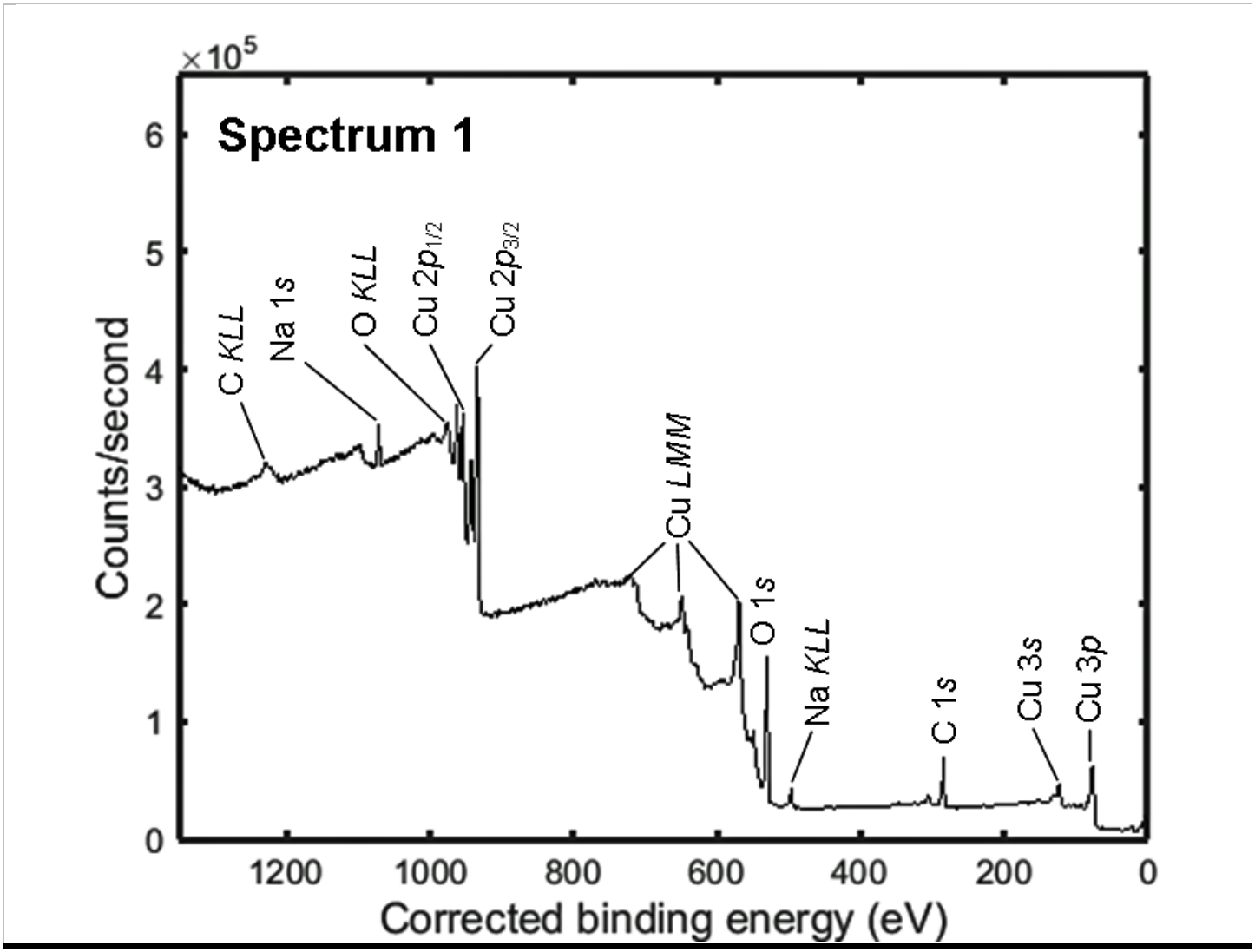
ANALYZER CALIBRATION TABLE

Spectrum ID #	Element/ Transition	Peak Energy (eV)	Peak Width FWHM (eV)	Peak Area (eV x cts/s)	Sensitivity Factor	Concentration (at. %)	Peak Assignment
11	Ag $3d_{5/2}$	368.4	0.51	71961	5.987	100	Ag
13	Au $4f_{7/2}$	84.0	0.60	314838	6.250	100	Au
15	Cu $2p_{3/2}$	933.0	0.80	401503	5.321	100	Cu

GUIDE TO FIGURES					
Spectrum (Accession) #	**Spectral Region**	**Voltage Shift***	**Multiplier**	**Baseline**	**Comment #**
01	Survey	-0.009	1	0	1
02	C 1s	-0.009	1	0	1
02	C 1s	-0.009	1	0	1
03	O 1s	-0.009	1	0	1
03	O 1s	-0.009	1	0	1
04	Cu 2p	-0.009	1	0	1
04	Cu 2p	-0.009	1	0	1
05	Survey	-3.146	1	0	2
06	C 1s	-3.146	1	0	2
06	C 1s	-3.146	1	0	2
07	O 1s	-3.146	1	0	2
07	O 1s	-3.146	1	0	2
08	Cu 2p	-3.146	1	0	2
08	Cu 2p	-3.146	1	0	2
09	In 3d	-3.146	1	0	2
09	In 3d	-3.146	1	0	2
10	Survey	0.000	1	0	4
11	Ag $3d_{5/2}$	0.000	1	0	4
12	Survey	0.000	1	0	5
13	Au $4f_{7/2}$	0.000	1	0	5
14	Survey	0.000	1	0	6
15	Cu $2p_{3/2}$	0.000	1	0	6

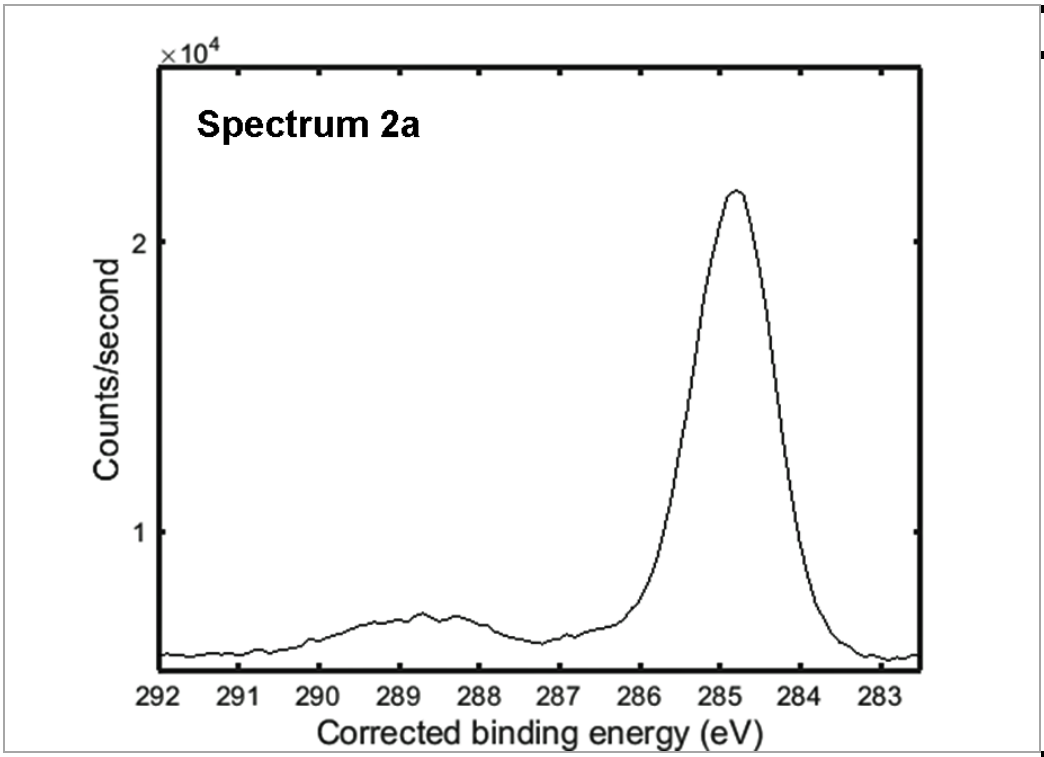
*Voltage shift of the archived (as-measured) spectrum relative to the printed figure. The figure reflects the recommended energy scale correction due to a calibration correction, sample charging, flood gun, or other phenomenon

1. CuAc.
2. CuO on MWCNTs.
3. Ag calibration.
4. Au calibration.
5. Cu calibration.



Publish in *Surface Science Spectra*: Yes ☒ No ☐

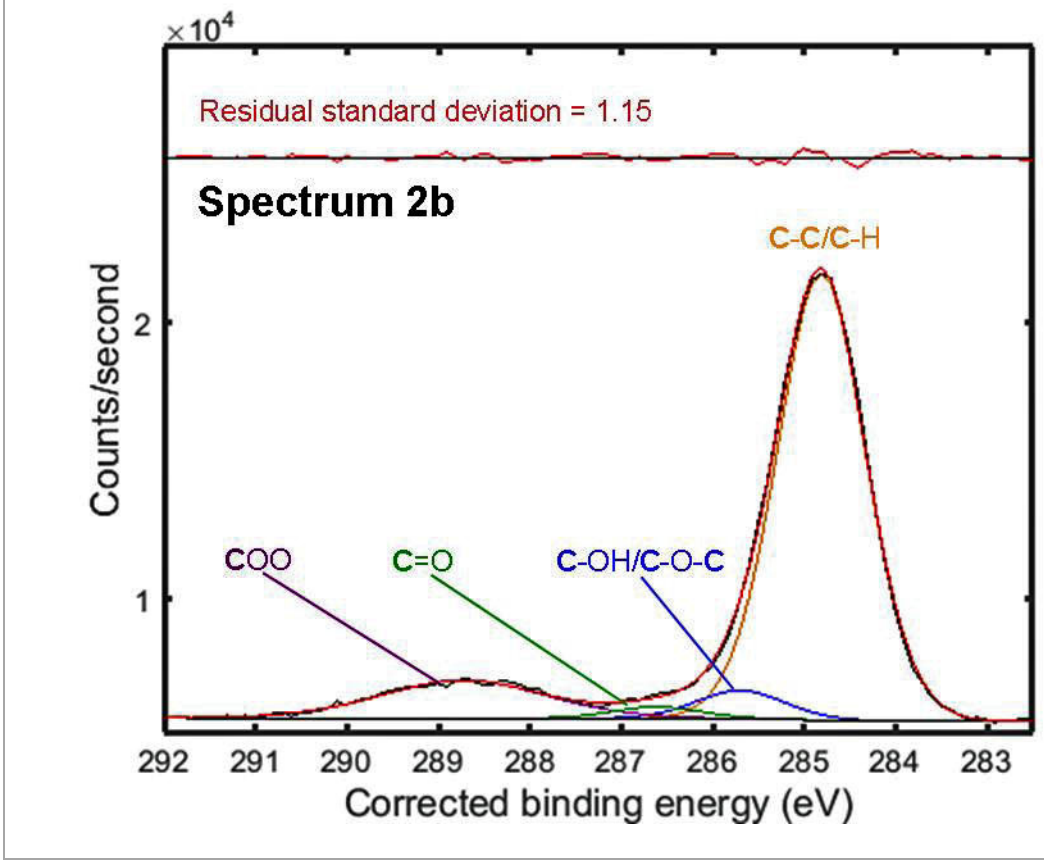
Accession #	**01312–01**
Host Material	CuAc
Technique	XPS
Spectral Region	survey
Instrument	Kratos Axis Supra
Excitation Source	Al Ka monochromatic
Source Energy	1486.6 eV
Source Strength	225 W
Source Size	0.7 mm x 0.3 mm
Analyzer Type	spherical sector analyzer
Incident Angle	54.7˚
Emission Angle	0˚
Analyzer Pass Energy	160 eV
Analyzer Resolution	1 eV
Total Signal Accumulation Time	120 s
Total Elapsed Time	120 s
Number of Scans	1
Effective Detector Width	16 eV



Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuAc
- **Technique:** XPS
- **Spectral Region:** C 1s

Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 332 s
Total Elapsed Time: Not specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

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- **Host Material:** CuAc
- **Technique:** XPS
- **Spectral Region:** C 1s

Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
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Source Size: 0.7 mm x 0.3 mm
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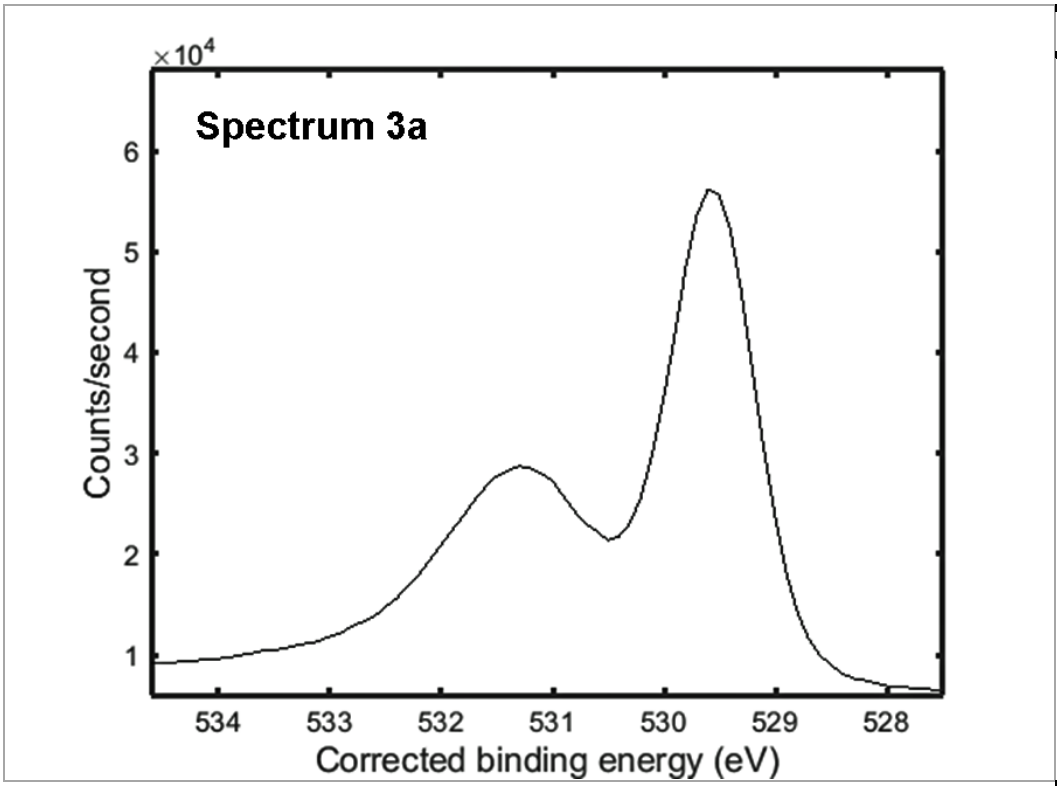
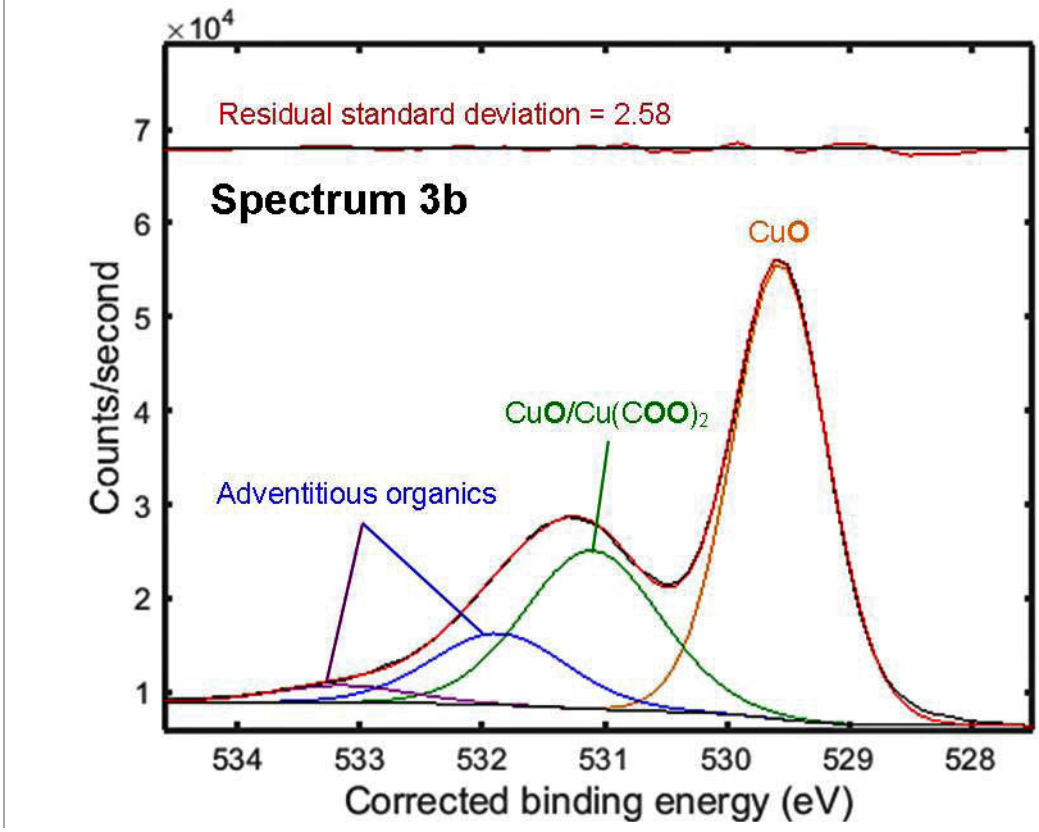


Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuAc
- **Technique:** XPS
- **Spectral Region:** O 1s

Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 347 s
Total Elapsed Time: Not specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuAc
- **Technique:** XPS
- **Spectral Region:** O 1s

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Excitation Source: Al Ka monochromatic
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Source Strength: 225 W
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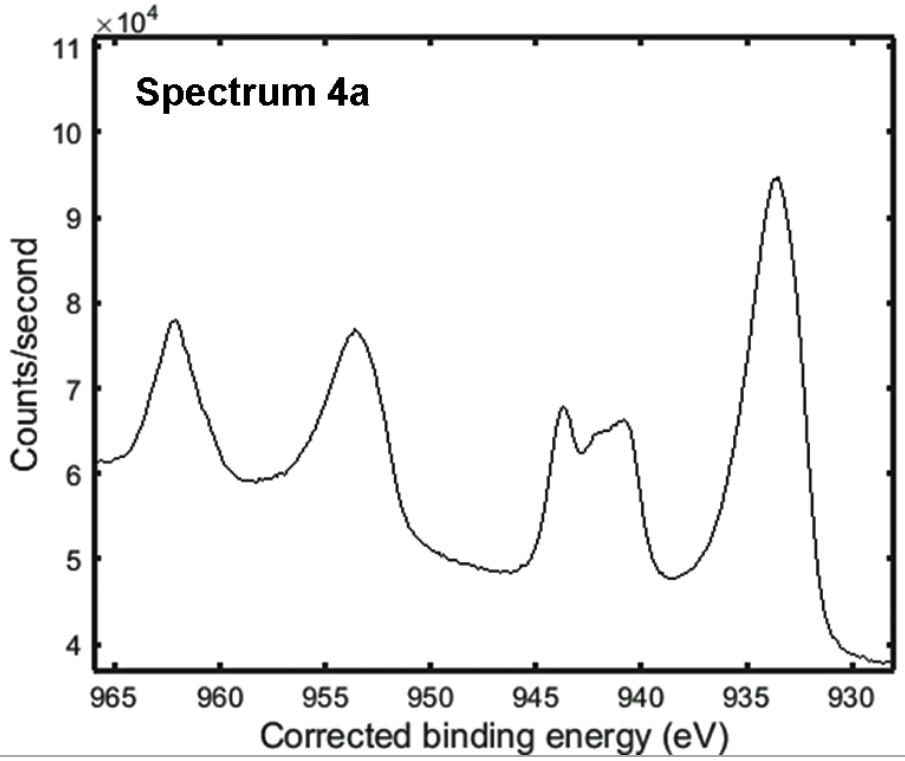
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 347 s
Total Elapsed Time: Not specified s
Number of Scans: 1

Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

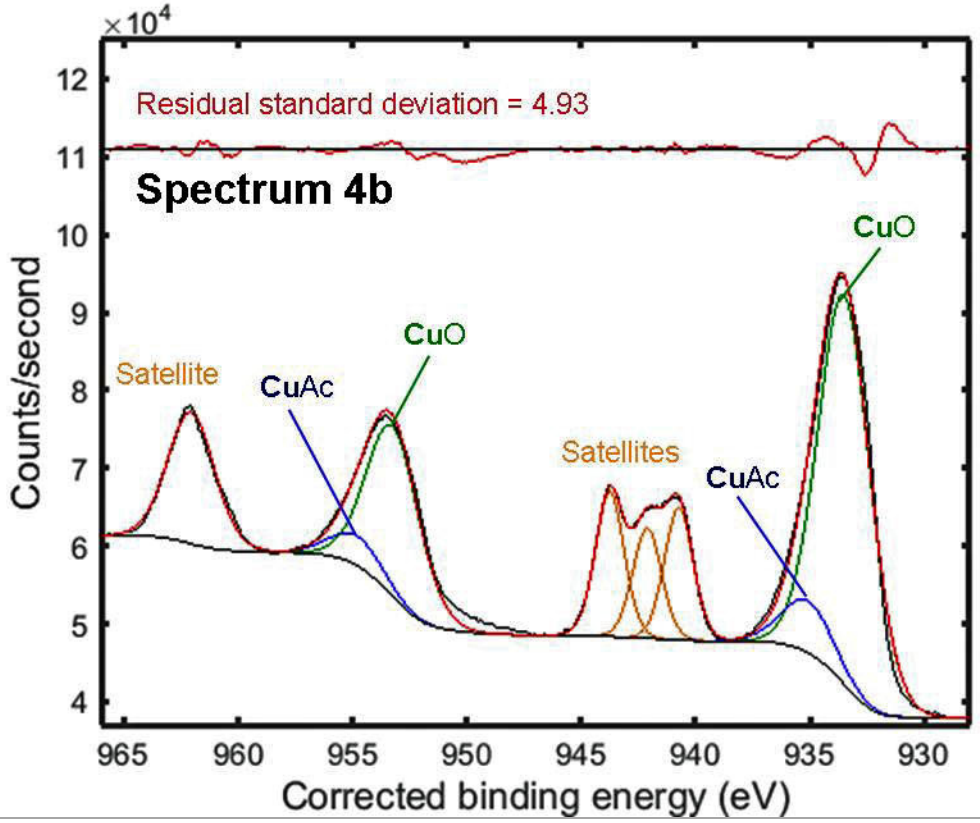
- **Accession #:**
- **Host Material:** CuAc
- **Technique:** XPS
- **Spectral Region:** Cu 2p

Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 3758 s
Total Elapsed Time: Not Specified s
Number of Scans: 1
Effective Detector Width: 2 eV

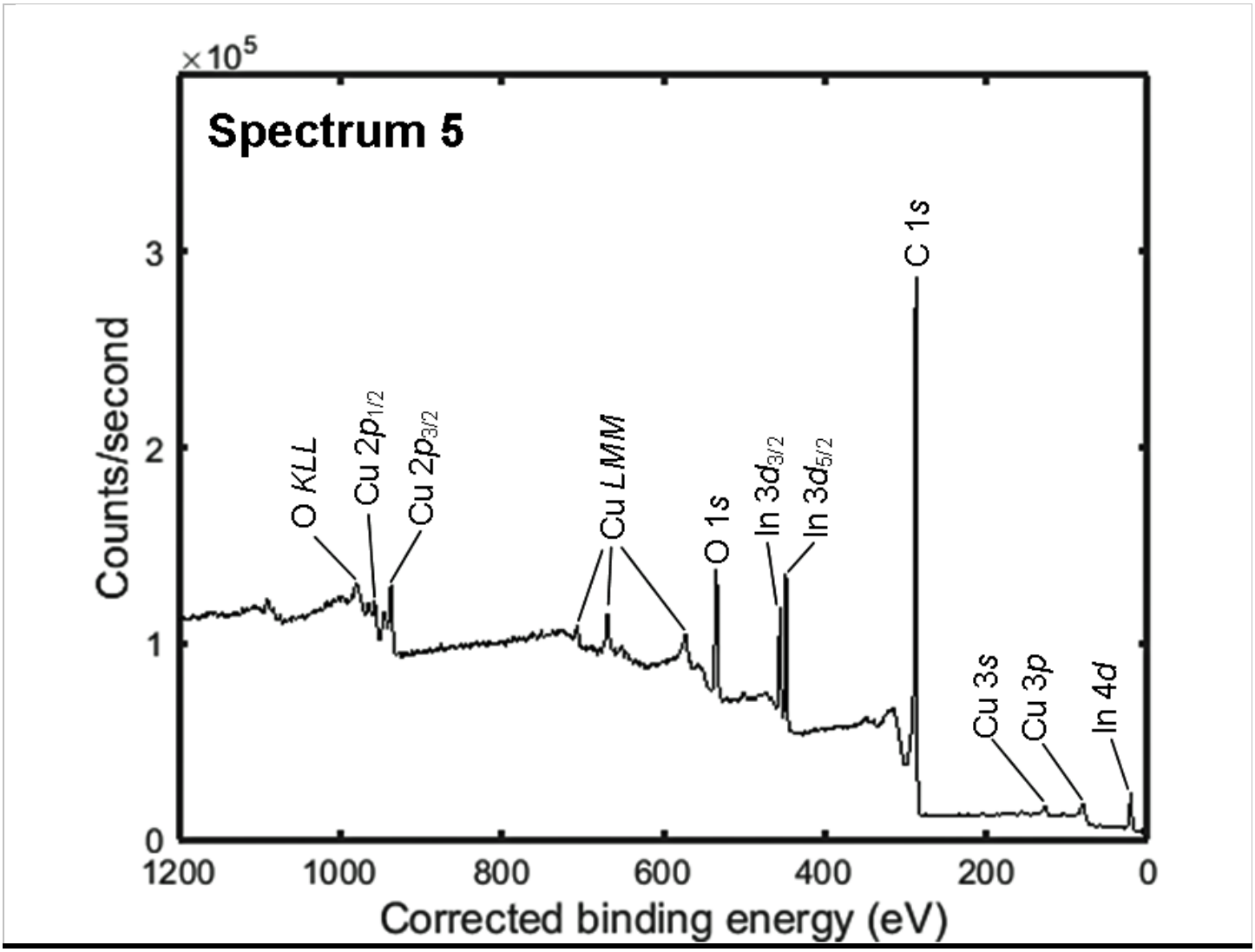
Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuAc
- **Technique:** XPS
- **Spectral Region:** Cu 2p

Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °



Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 3758 s
Total Elapsed Time: Not specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *Surface Science Spectra*: Yes ☒ No ☐

Accession #	**01312–01**
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Spectral Region	survey
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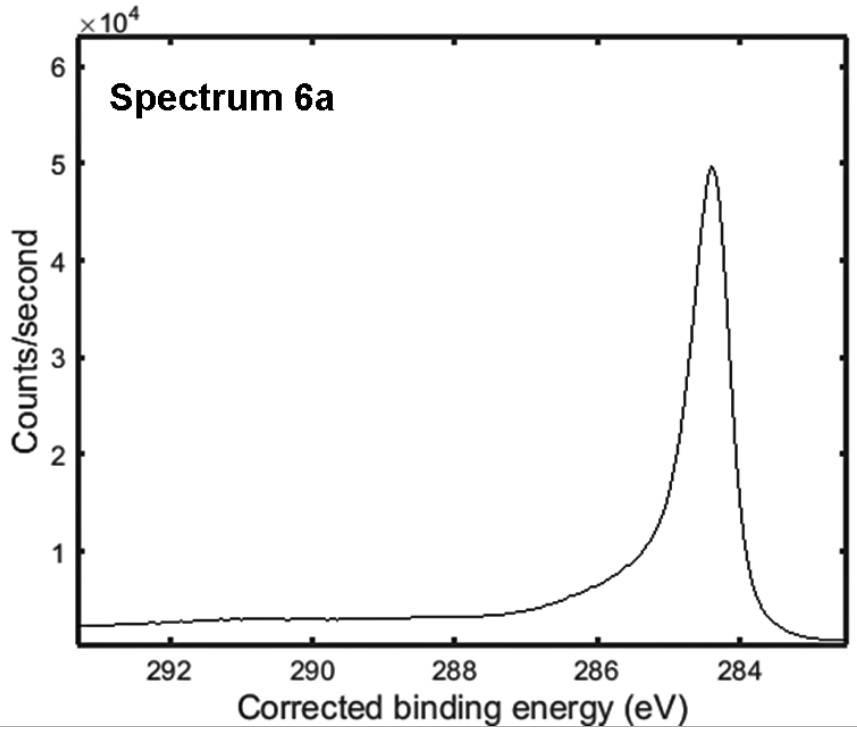

Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuO on MWCNTs
- **Technique:** XPS
- **Spectral Region:** C 1s

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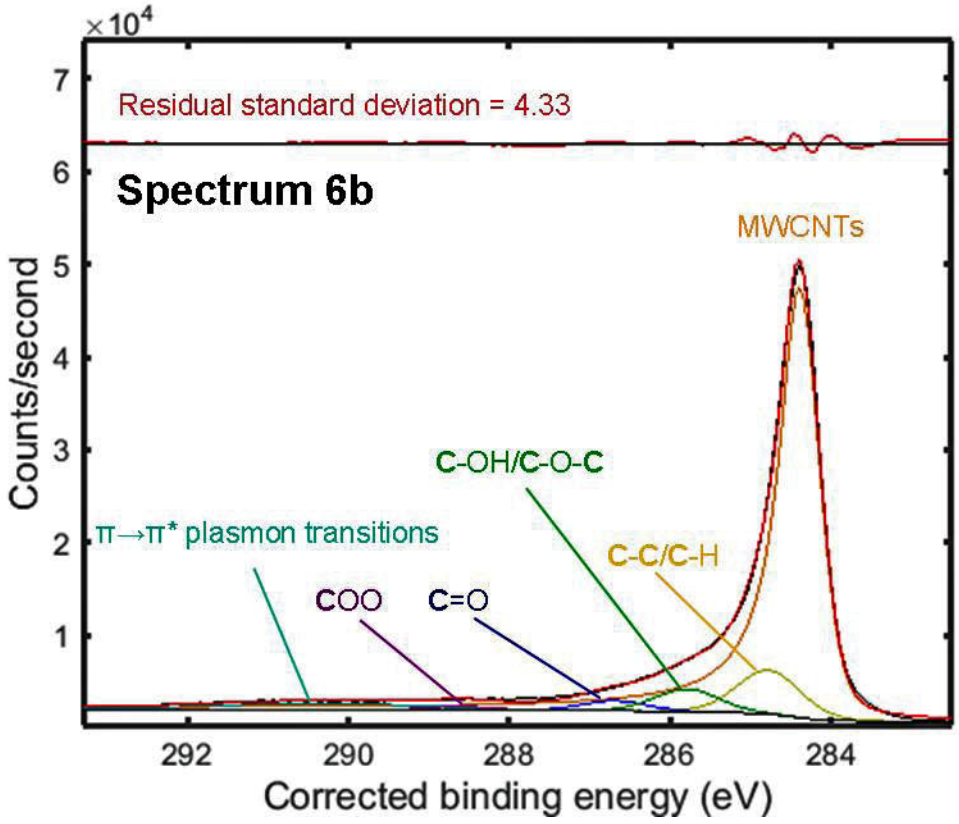

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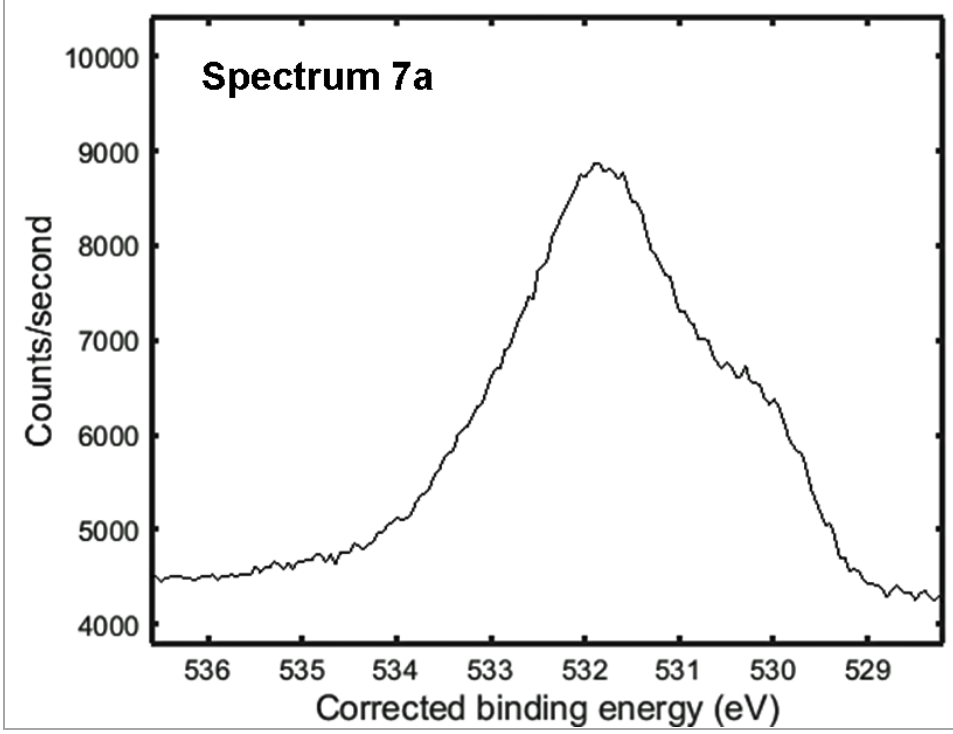
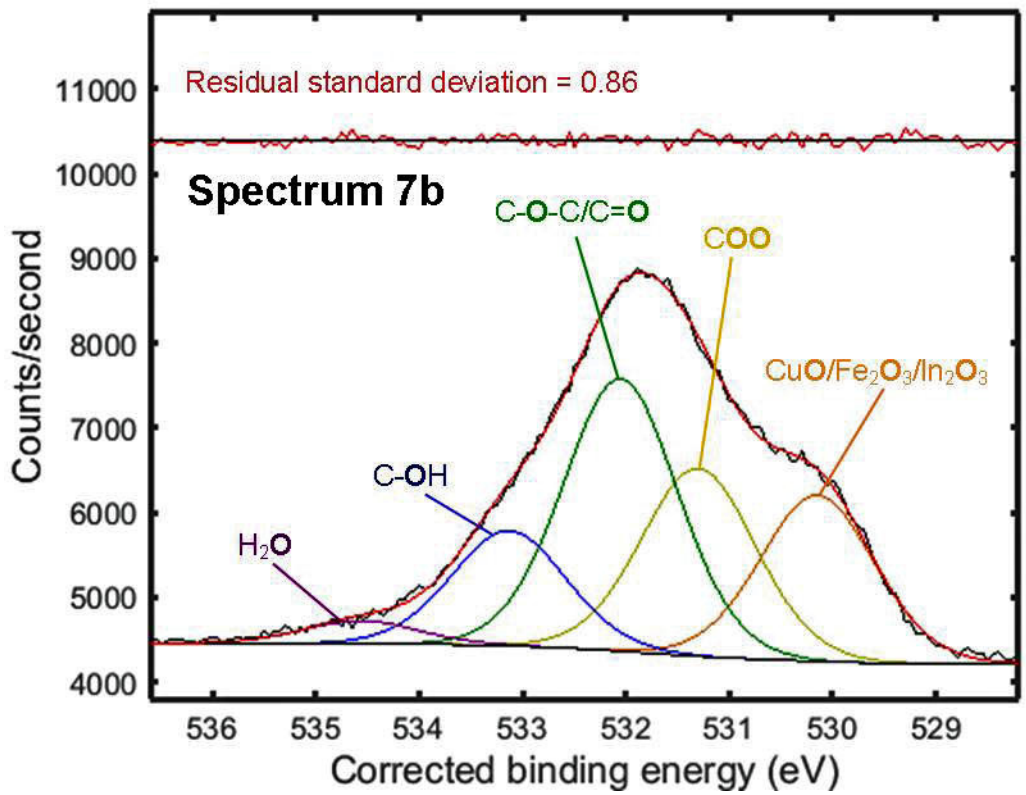
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 332 s
Total Elapsed Time: Not Specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuO on MWCNTs
- **Technique:** XPS
- **Spectral Region:** O 1s

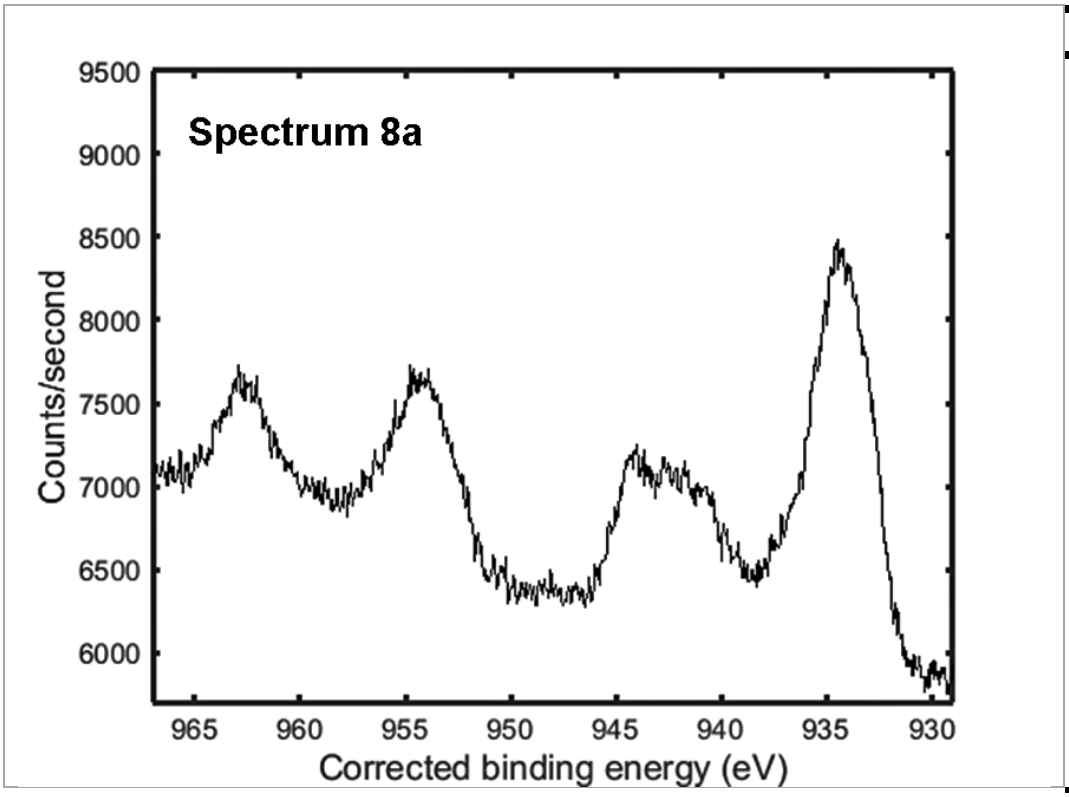
Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 347 s
Total Elapsed Time: Not Specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuO on MWCNTs
- **Technique:** XPS
- **Spectral Region:** O 1s

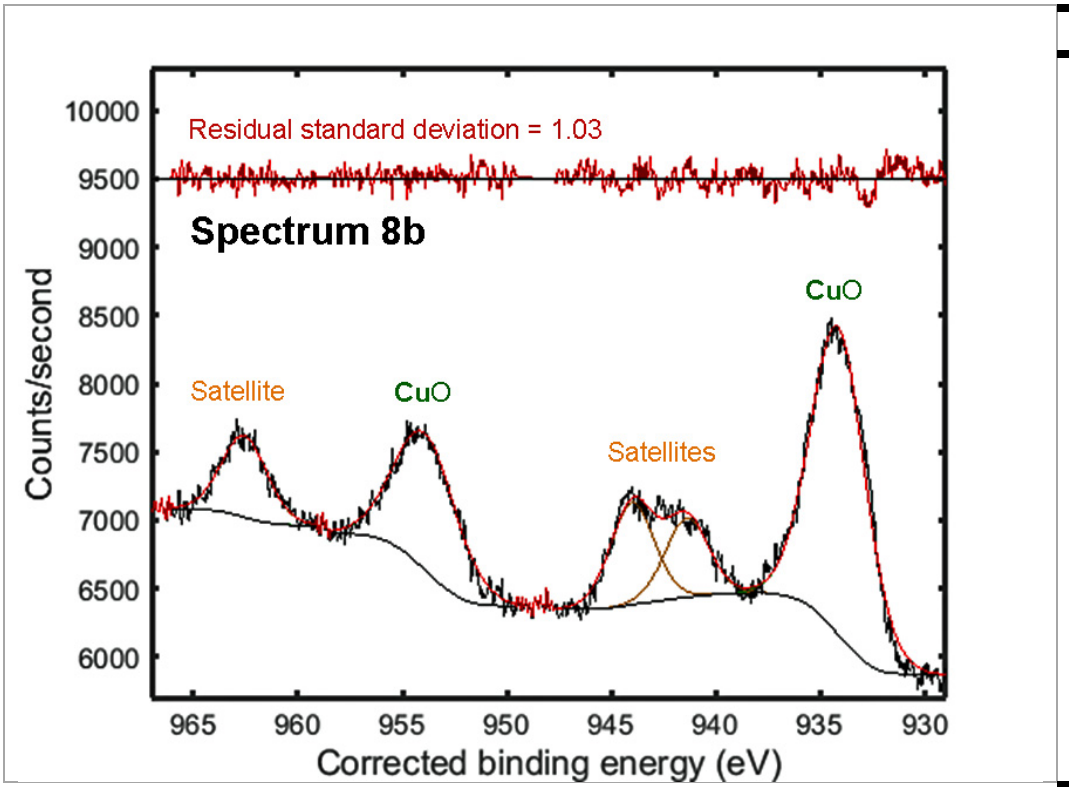
Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 347 s
Total Elapsed Time: Not Specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuO on MWCNTs
- **Technique:** XPS
- **Spectral Region:** Cu 2p

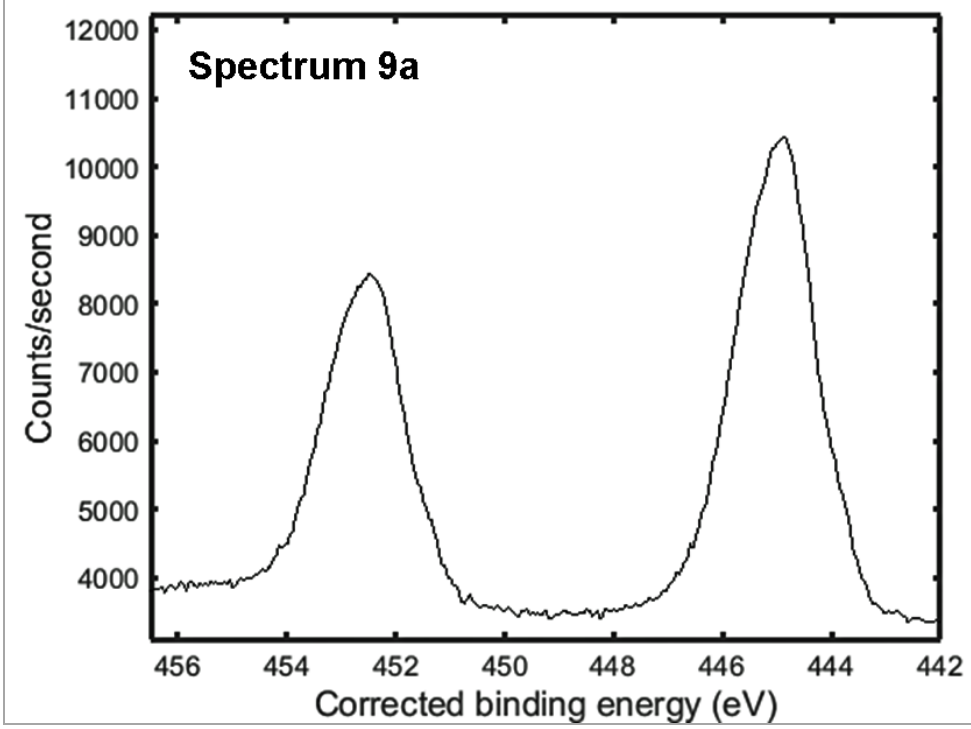
Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 3758 s
Total Elapsed Time: Not Specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuO on MWCNTs
- **Technique:** XPS
- **Spectral Region:** Cu 2p

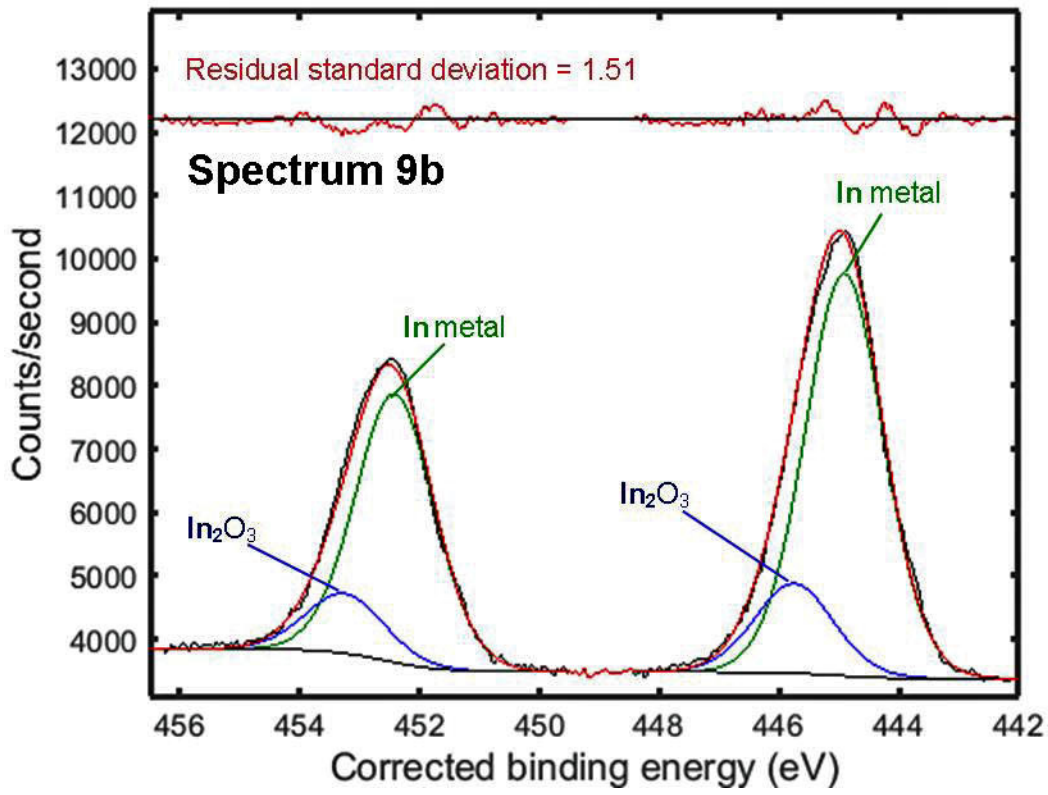
Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 3758 s
Total Elapsed Time: Not Specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

- **Accession #:**
- **Host Material:** CuO on MWCNTs
- **Technique:** XPS
- **Spectral Region:** In 3d

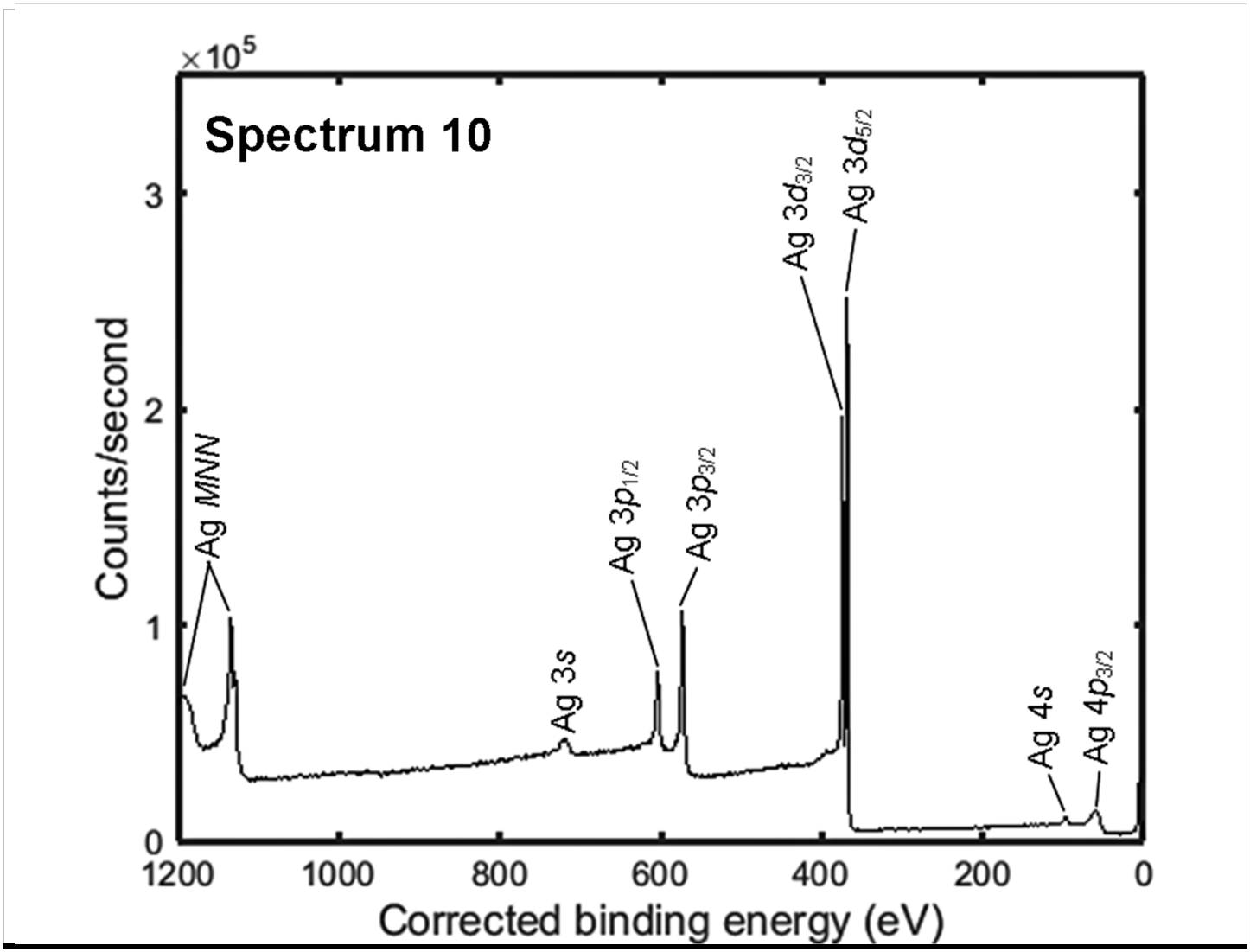
Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 116 s
Total Elapsed Time: Not Specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *SSS*: Yes ☒ No ☐

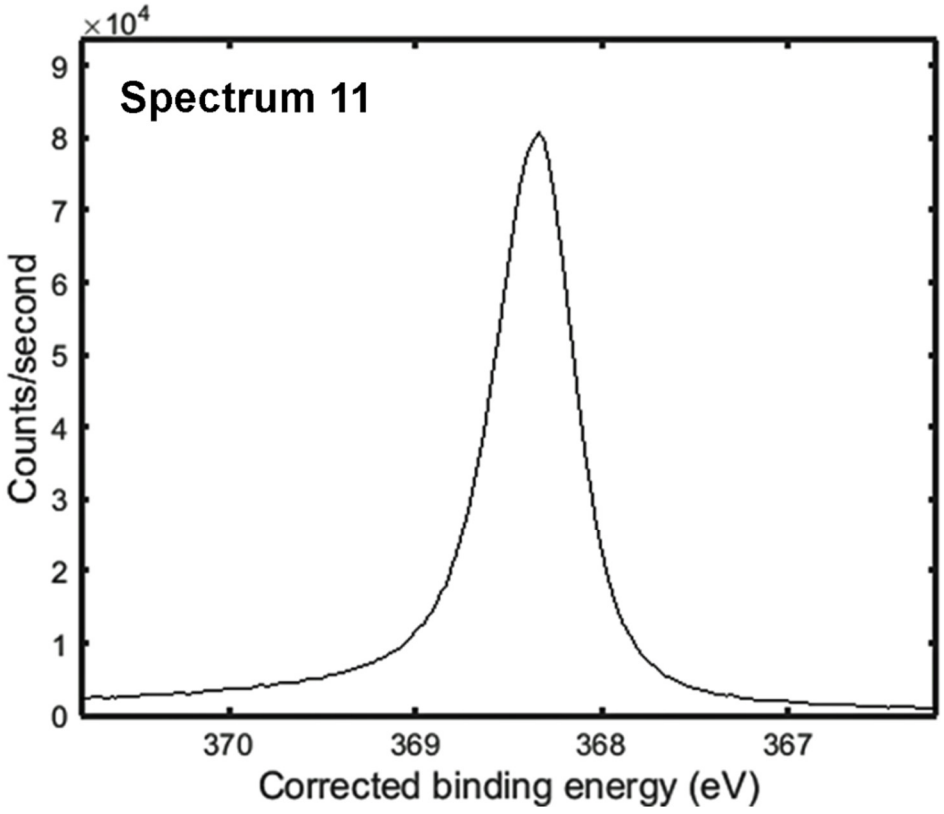
- **Accession #:**
- **Host Material:** CuO on MWCNTs
- **Technique:** XPS
- **Spectral Region:** In 3d

Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV
Source Strength: 225 W
Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °
Emission Angle: 0 °
Analyzer Pass Energy 20 eV
Analyzer Resolution: 0.616 eV
Total Signal Accumulation Time: 116 s
Total Elapsed Time: Not Specified s
Number of Scans: 1
Effective Detector Width: 2 eV



Publish in *Surface Science Spectra*: Yes ☐ No ☒

Accession #	
Host Material	Ag calibration
Technique	XPS
Spectral Region	survey
Instrument	Kratos Axis Supra
Excitation Source	Al Ka monochromatic
Source Energy	1486.6 eV
Source Strength	15 W
Source Size	0.7 mm x 0.3 mm
Analyzer Type	spherical sector analyzer
Incident Angle	54.7˚
Emission Angle	0˚
Analyzer Pass Energy	160 eV
Analyzer Resolution	1 eV
Total Signal Accumulation Time	120 s
Total Elapsed Time	120 s
Number of Scans	1
Effective Detector Width	16 eV



Publish in *SSS*: Yes ☐ No ☒

■ **Accession #:**

■ **Host Material:** Ag calibration

■ **Technique:** XPS

■ **Spectral Region:** Ag 3d5/2

Instrument: Kratos Axis Supra
Excitation Source: Al Ka monochromatic
Source Energy: 1486.6 eV

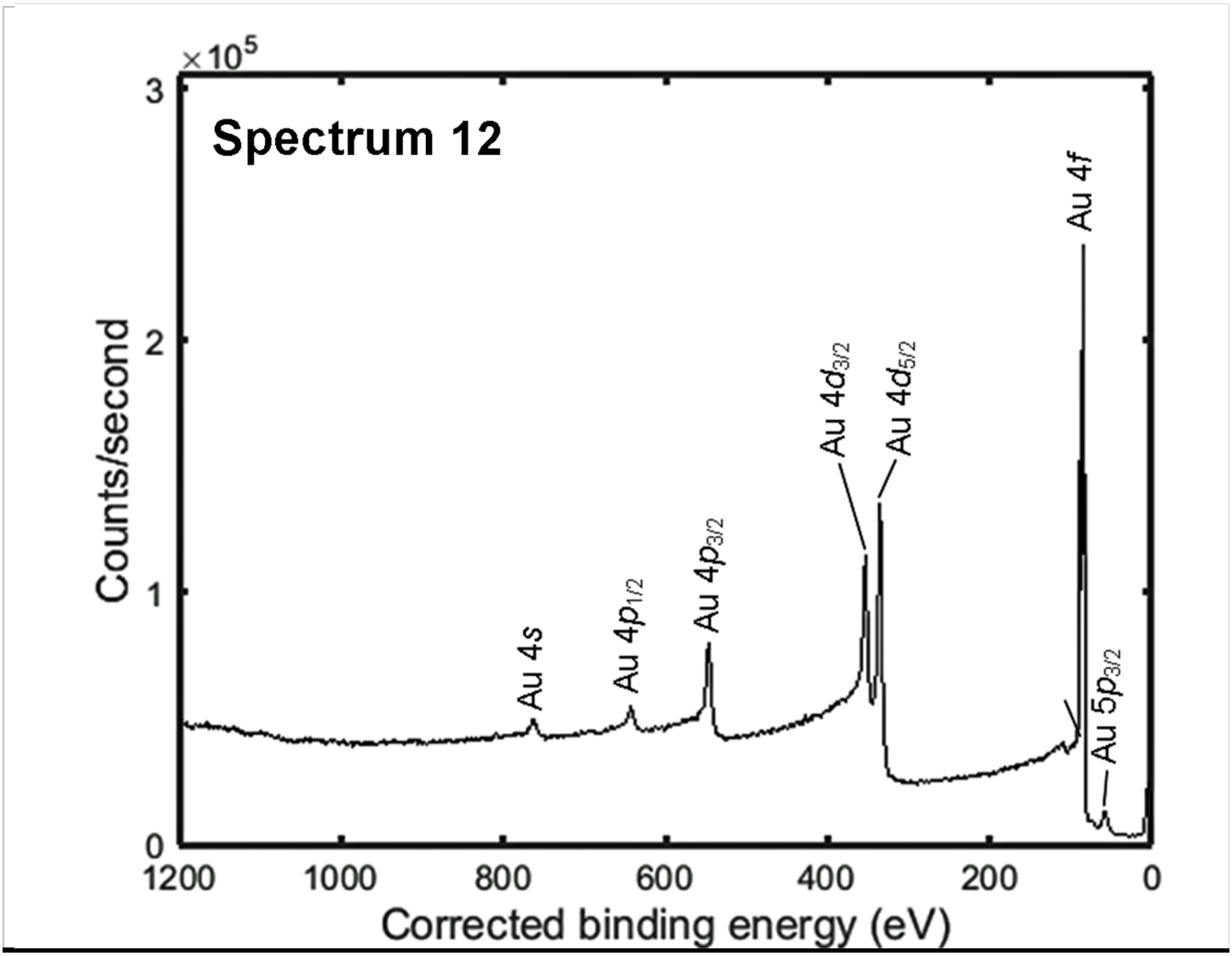
Source Strength: 60 W

Source Size: 0.7 mm x 0.3 mm
Analyzer Type: spherical sector
Incident Angle: 54.7 °

Emission Angle: 0 °

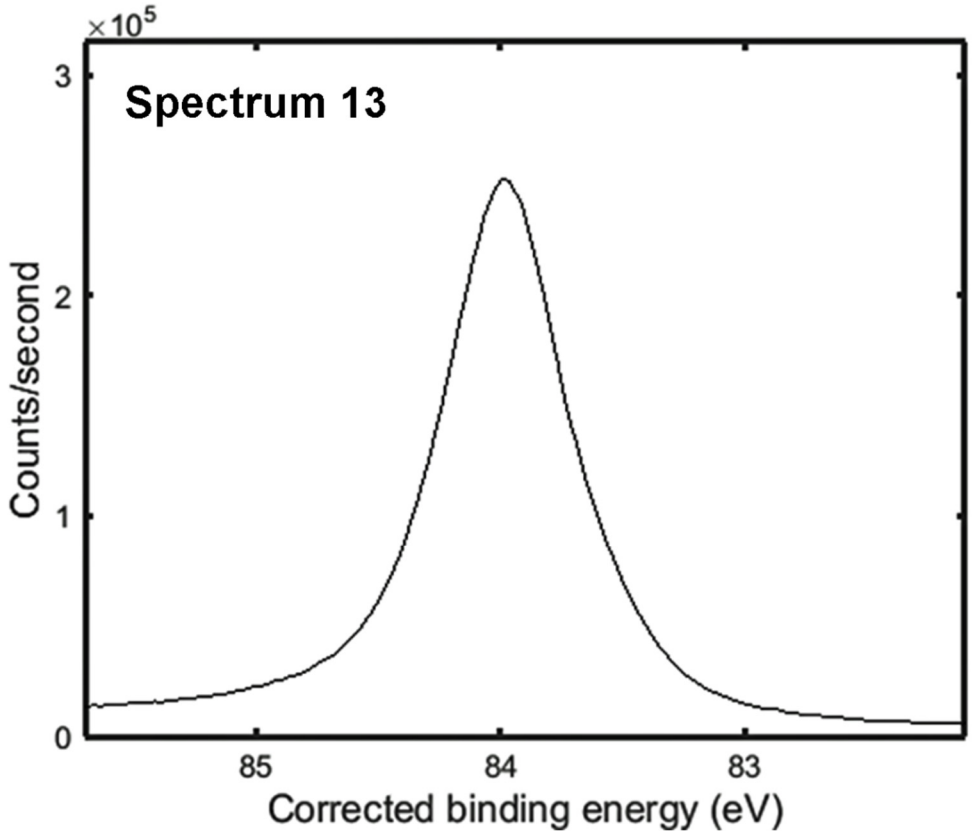
Analyzer Pass Energy 10 eV

Analyzer Resolution: 0.498 eV
Total Signal Accumulation Time: 84 s
Total Elapsed Time: Not specified
Number of Scans: 1
Effective Detector Width: 1 eV



Publish in *Surface Science Spectra*: Yes ☐ No ☒

Accession #	
Host Material	Au calibration
Technique	XPS
Spectral Region	survey
Instrument	Kratos Axis Supra
Excitation Source	Al Ka monochromatic
Source Energy	1486.6 eV
Source Strength	15 W
Source Size	0.7 mm x 0.3 mm
Analyzer Type	spherical sector analyzer
Incident Angle	54.7˚
Emission Angle	0˚
Analyzer Pass Energy	160 eV
Analyzer Resolution	1 eV
Total Signal Accumulation Time	120 s
Total Elapsed Time	120 s
Number of Scans	1
Effective Detector Width	16 eV



Publish in *SSS*: Yes ☐ No ☒

■ **Accession #:**

■ **Host Material:** Au calibration

■ **Technique:** XPS

■ **Spectral Region:** Au 4f7/2

Instrument: Kratos Axis Supra

Excitation Source: Al Ka monochromatic

Source Energy: 1486.6 eV

Source Strength: 300 W

Source Size: 0.7 mm x 0.3 mm

Analyzer Type: spherical sector

Incident Angle: 54.7 °

Emission Angle: 0 °

Analyzer Pass Energy 10 eV

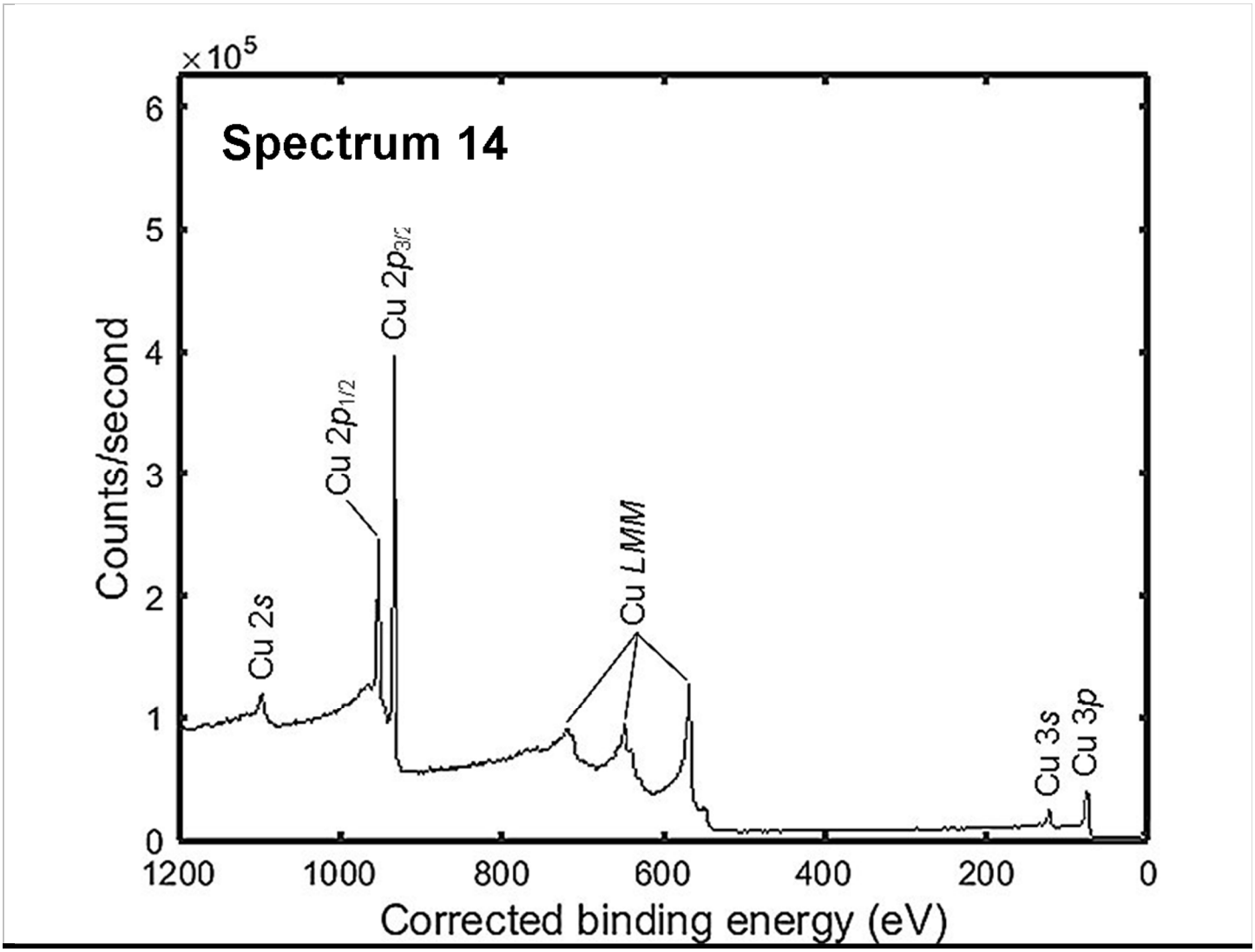
Analyzer Resolution: 0.596 eV

Total Signal Accumulation Time: 50 s

Total Elapsed Time: Not specified

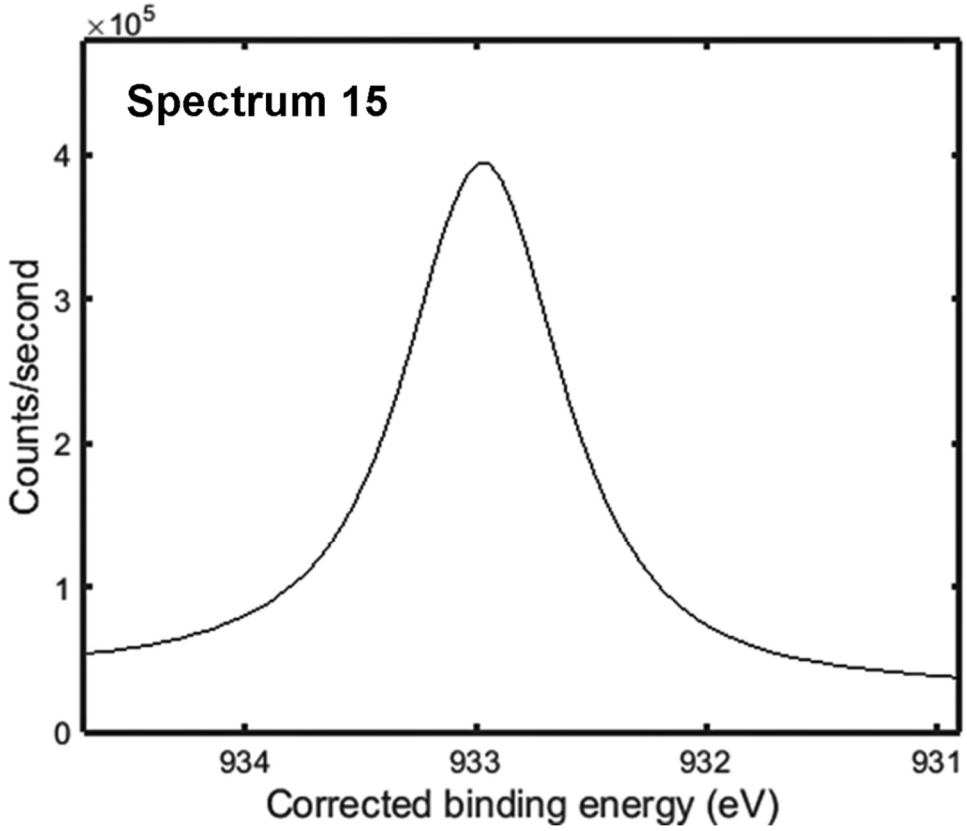
Number of Scans: 1

Effective Detector Width: 1 eV



Publish in *Surface Science Spectra*: Yes ☐ No ☒

Accession #	
Host Material	Cu calibration
Technique	XPS
Spectral Region	survey
Instrument	Kratos Axis Supra
Excitation Source	Al Ka monochromatic
Source Energy	1486.6 eV
Source Strength	15 W
Source Size	0.7 mm x 0.3 mm
Analyzer Type	spherical sector analyzer
Incident Angle	54.7˚
Emission Angle	0˚
Analyzer Pass Energy	160 eV
Analyzer Resolution	1 eV
Total Signal Accumulation Time	120 s
Total Elapsed Time	120 s
Number of Scans	1
Effective Detector Width	16 eV



Publish in *SSS*: Yes ☐ No ☒

■ **Accession #:**

■ **Host Material:** Cu calibration

■ **Technique:** XPS

■ **Spectral Region:** Cu 2p3/2

Instrument: Kratos Axis Supra

Excitation Source: Al Ka monochromatic

Source Energy: 1486.6 eV

Source Strength: 300 W

Source Size: 0.7 mm x 0.3 mm

Analyzer Type: spherical sector

Incident Angle: 54.7 °

Emission Angle: 0 °

Analyzer Pass Energy 10 eV

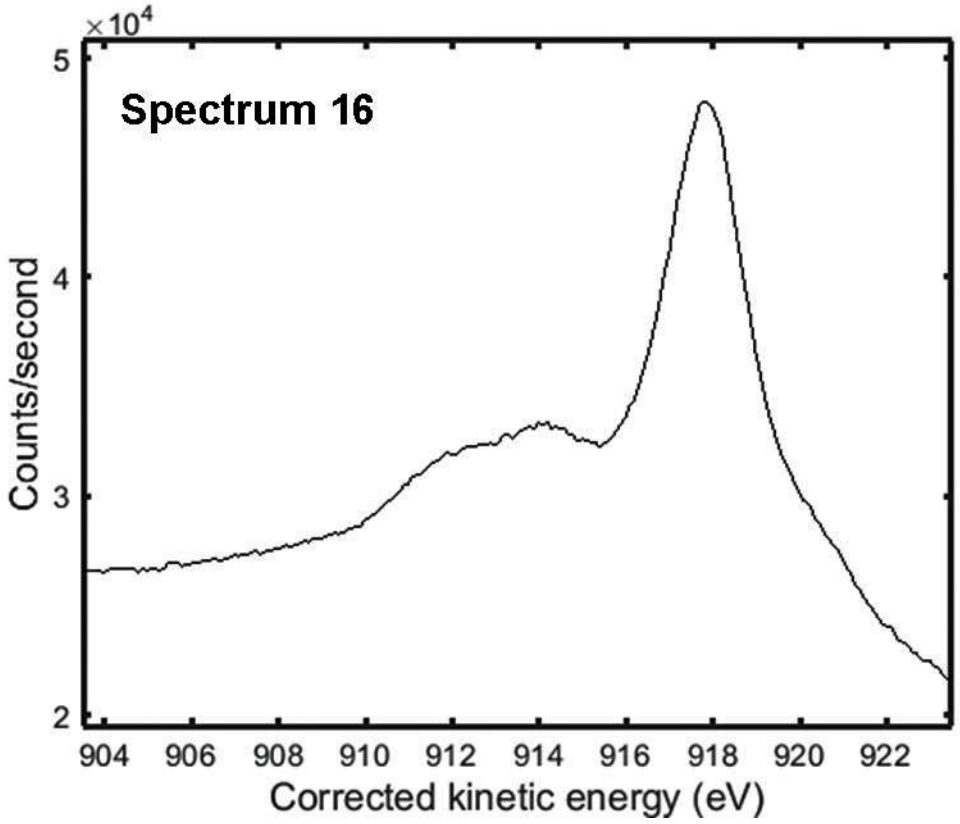
Analyzer Resolution: 0.796 eV

Total Signal Accumulation Time: 50 s

Total Elapsed Time: Not specified

Number of Scans: 1

Effective Detector Width: 1 eV



Publish in *SSS*: Yes ☐ No ☒

■ **Accession #:**

■ **Host Material:** Au calibration

■ **Technique:** XPS

■ **Spectral Region:** Cu LMM

Instrument: Kratos Axis Supra

Excitation Source: Al Ka monochromatic

Source Energy: 1486.6 eV

Source Strength: 300 W

Source Size: 0.7 mm x 0.3 mm

Analyzer Type: spherical sector

Incident Angle: 54.7 °

Emission Angle: 0 °

Analyzer Pass Energy 20 eV

Analyzer Resolution: 0.616 eV

Total Signal Accumulation Time: 118 s

Total Elapsed Time: Not specified

Number of Scans: 1

Effective Detector Width: 1 eV