CAT C13 Liner – Removal of Rust Preventative (RP) by Select Cleaning Methods

being essential

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1-29-2018

Outline

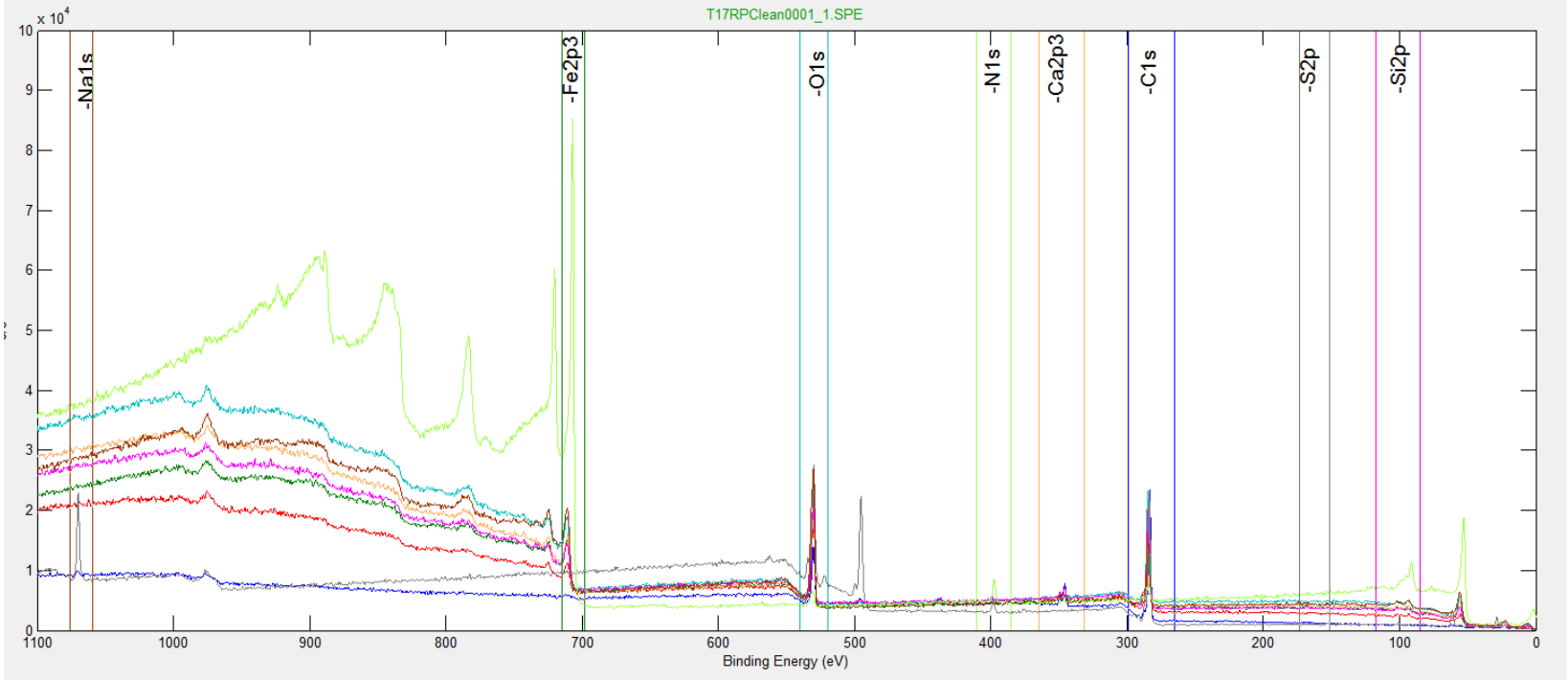
- CAT C13 liner samples were supplied to the Applied Sciences Group by Lubrizol Mechanical Testing and also as supplied directly from CAT to evaluate various cleaning methods used to remove the rust preventative.
- Samples from Mech Test Internal included:
  1. Rust preventative (RP) coated liner segments as received and cut into 1 inch squares.
  2. Duplicate samples of the same liner samples cleaned with the Lubrizol Tide/ Water method. The liner samples were subsequently coated with a mineral oil to prevent rust formation prior to the surface analysis.
  3. Duplicate samples of the same liner samples cleaned with WD-40 analyzed as cleaned.
  4. Duplicate samples of the same liner samples cleaned with Ensolv analyzed as cleaned.

Lubrizol

Outline

- Samples from CAT included:
  1. Samples marked “L #” cleaned with concentrated LAC 147 and cut into 1 inch squares.
  2. Samples marked “C #” control samples wiped with a rag.
- The Lubrizol samples cleaned with Tide/ Water were rinsed with hexane prior to analysis to remove the mineral oil.
- A duplicate Lubrizol sample cleaned with Tide/ Water and coated with mineral oil was also cleaned with hexane and then with isopropanol.
- Each sample was analyzed by X-ray Photoelectron Spectroscopy (XPS). The XPS depth of analysis is of the order 3-5nm and is representative of what is in the top couple atom layers on the liner surface.
- The cleanliness of the surface is directly related to how much iron from the cast iron substrate is visible from the XPS analysis.
- The as received samples with RP on the surface all contained Ca which was used as a chemical marker to identify whether the cleaning method was effective at removing the RP.

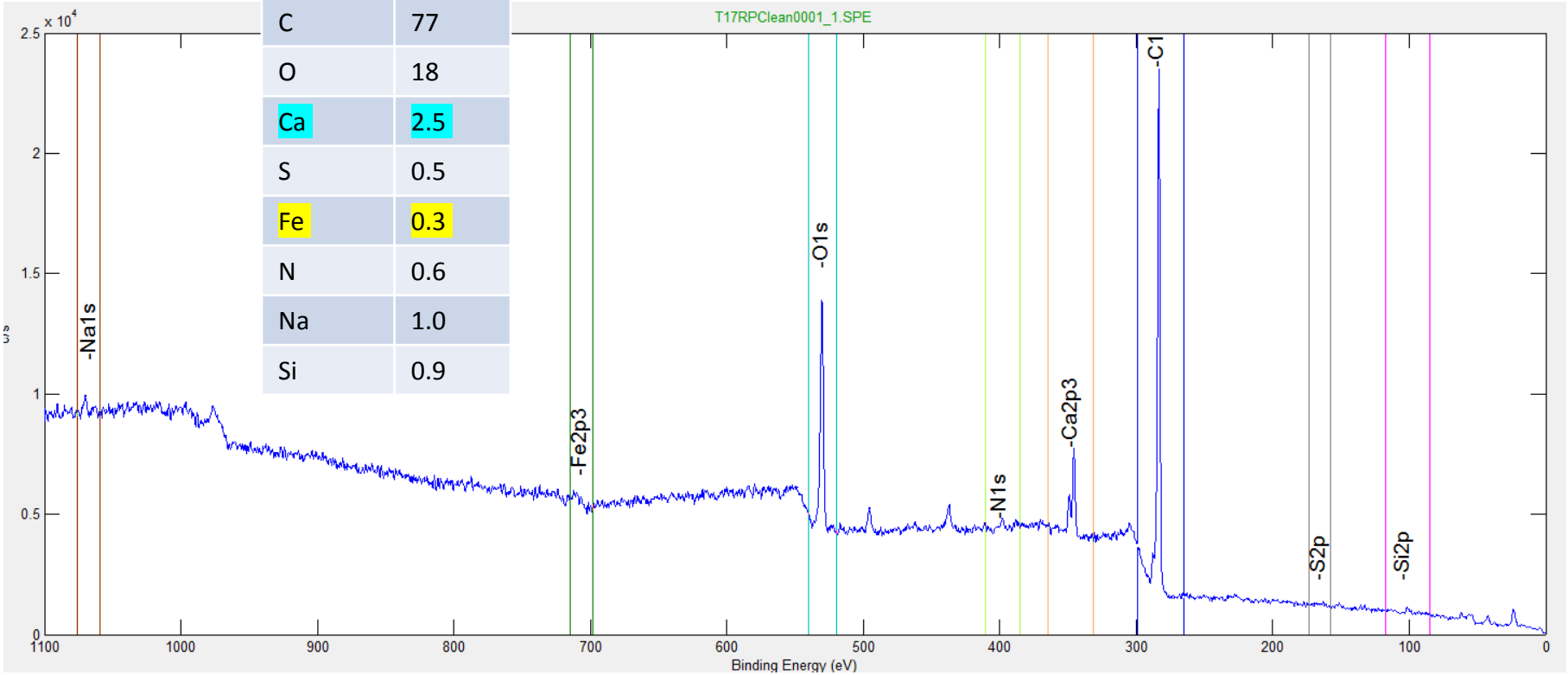
Results for all samples for comparison



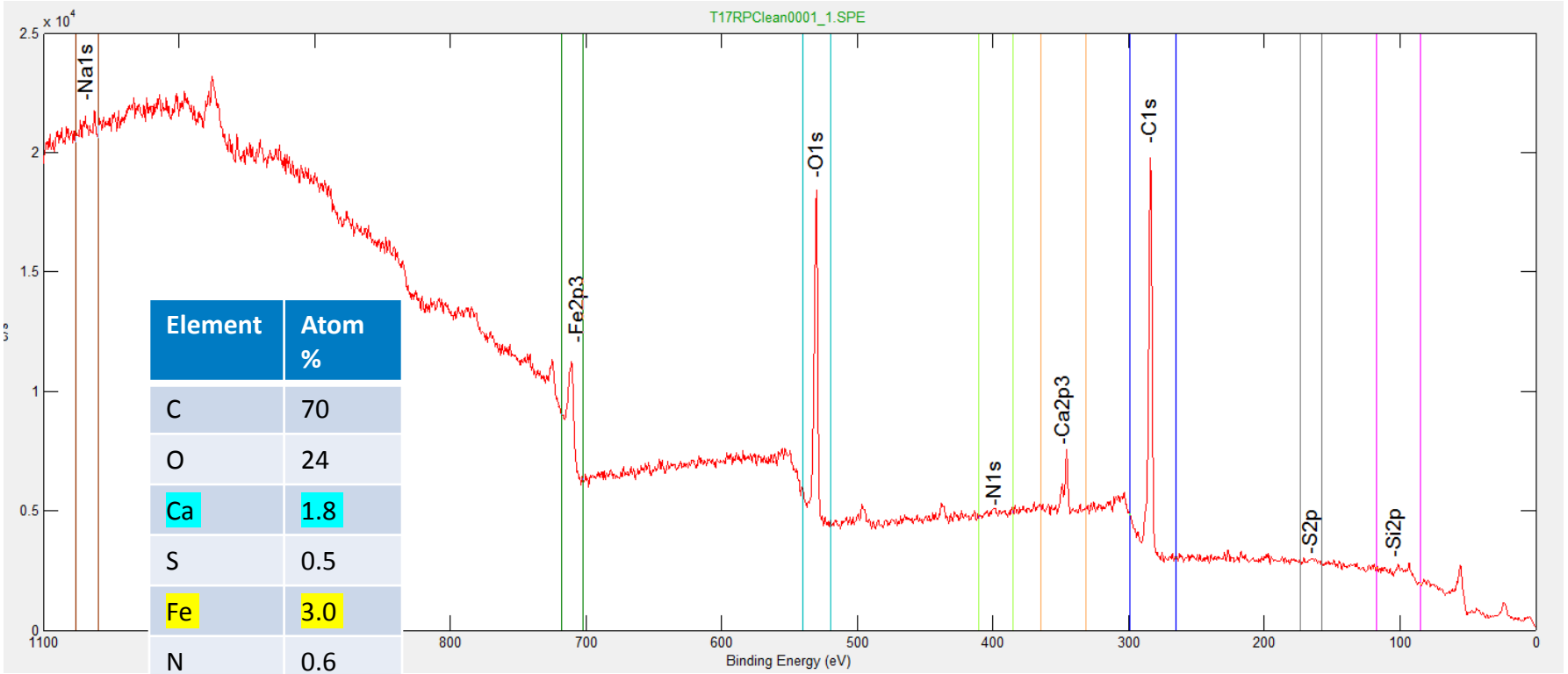
- XPS detects elements in only the top several atom layers.
- Only the primary elemental peak is highlighted for each element present.
- Fe and N are from the substrate liner material.
- C, O, Ca, and S are from the Castrol Rustilo DW300 (Ba free version of DW30X).
- C, O, Na, and Si are from the LAC 147.

Results for C13 liner samples – Mech Test as received

Element	Atom %
C	77
O	18
Ca	2.5
S	0.5
Fe	0.3
N	0.6
Na	1.0
Si	0.9

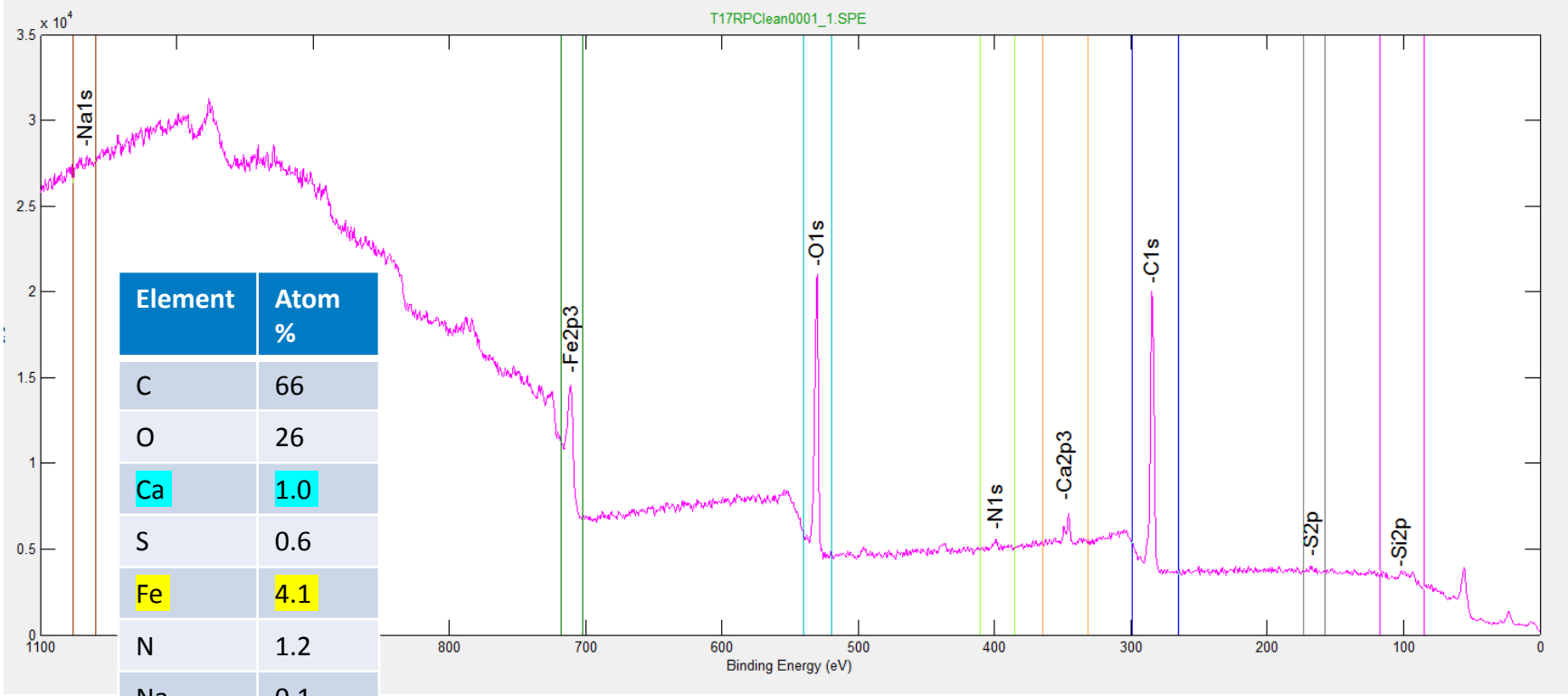


Results for C13 liner samples – Mech Test as received + rinsed with hexanes



Element	Atom %
C	70
O	24
Ca	1.8
S	0.5
Fe	3.0
N	0.6
Na	0.5
Si	0.6

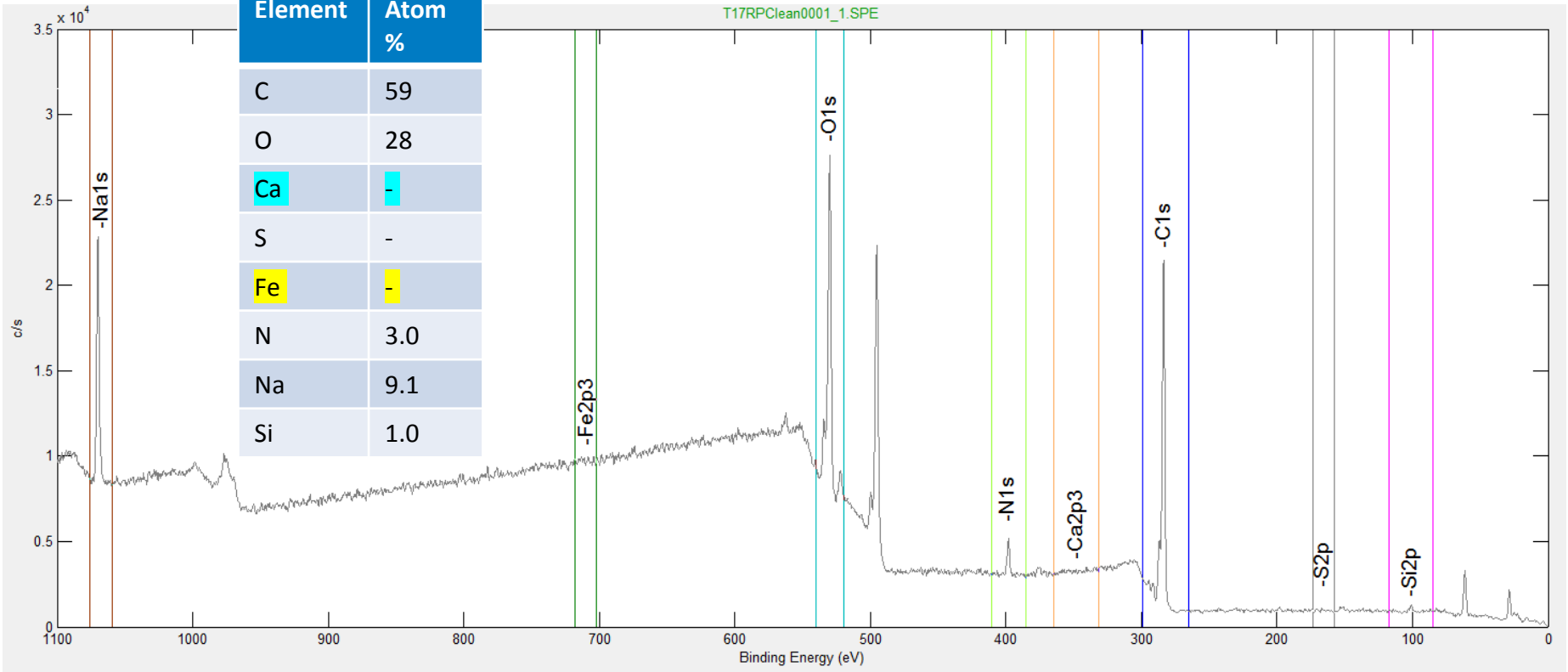
Results for C13 liner samples – CAT Control C1 wiped with a rag as received



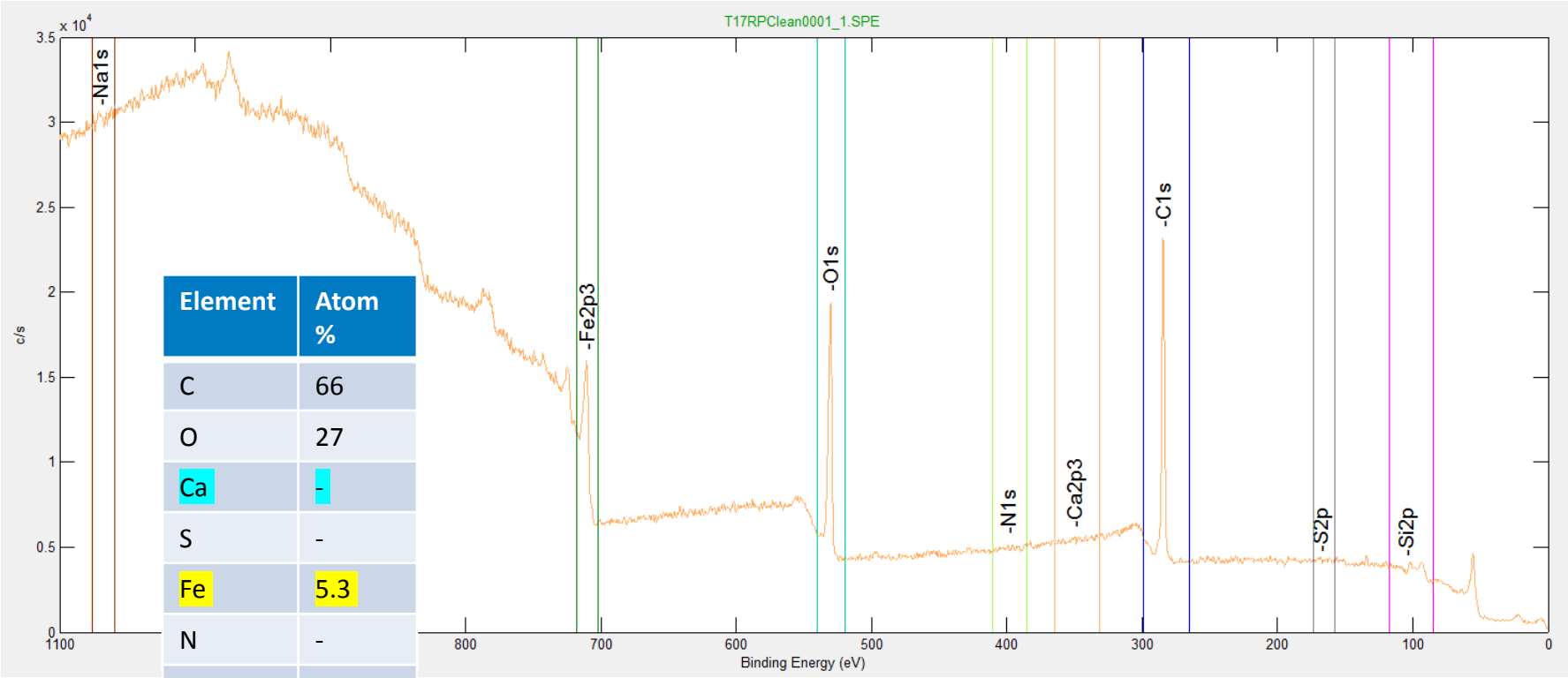
Element	Atom %
C	66
O	26
Ca	1.0
S	0.6
Fe	4.1
N	1.2
Na	0.1
Si	1.3

Results for C13 liner samples – CAT LAC 147 cleaned sample L4 as received

Element	Atom %
C	59
O	28
Ca	-
S	-
Fe	-
N	3.0
Na	9.1
Si	1.0

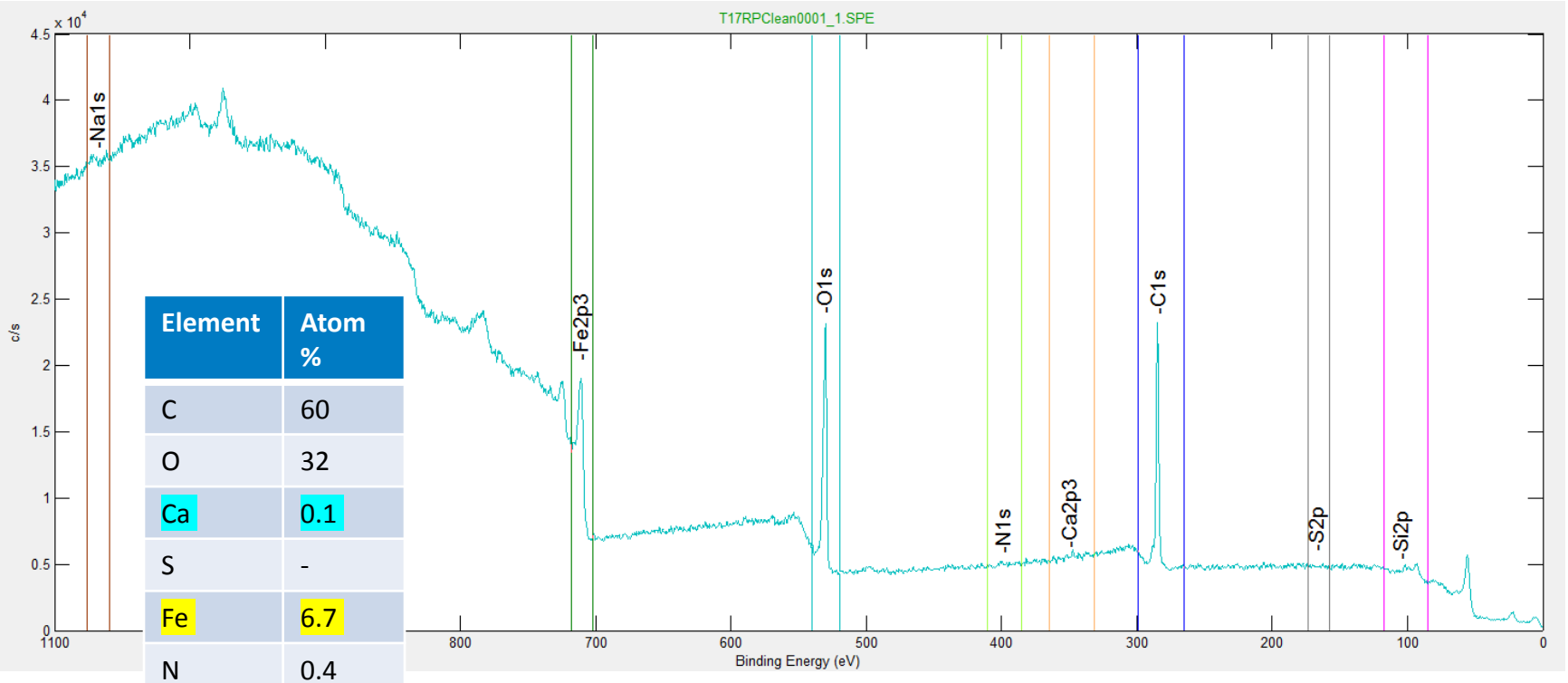


Results for C13 Liner samples – Lubrizol cleaned with WD-40 + rinsed in hexane



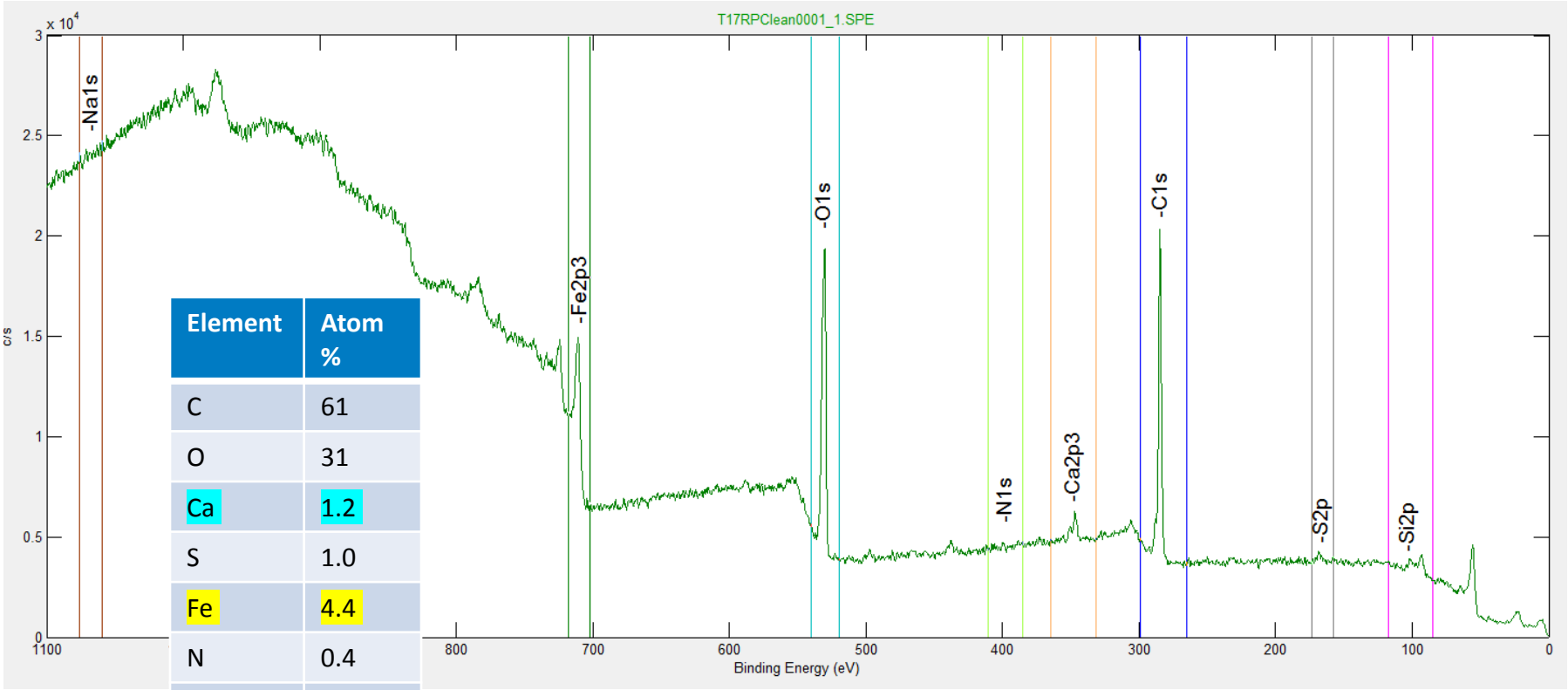
Element	Atom %
C	66
O	27
Ca	-
S	-
Fe	5.3
N	-
Na	0.5
Si	0.8

Results for C13 Liner samples – Lubrizol cleaned with Ensolv + rinsed in hexane



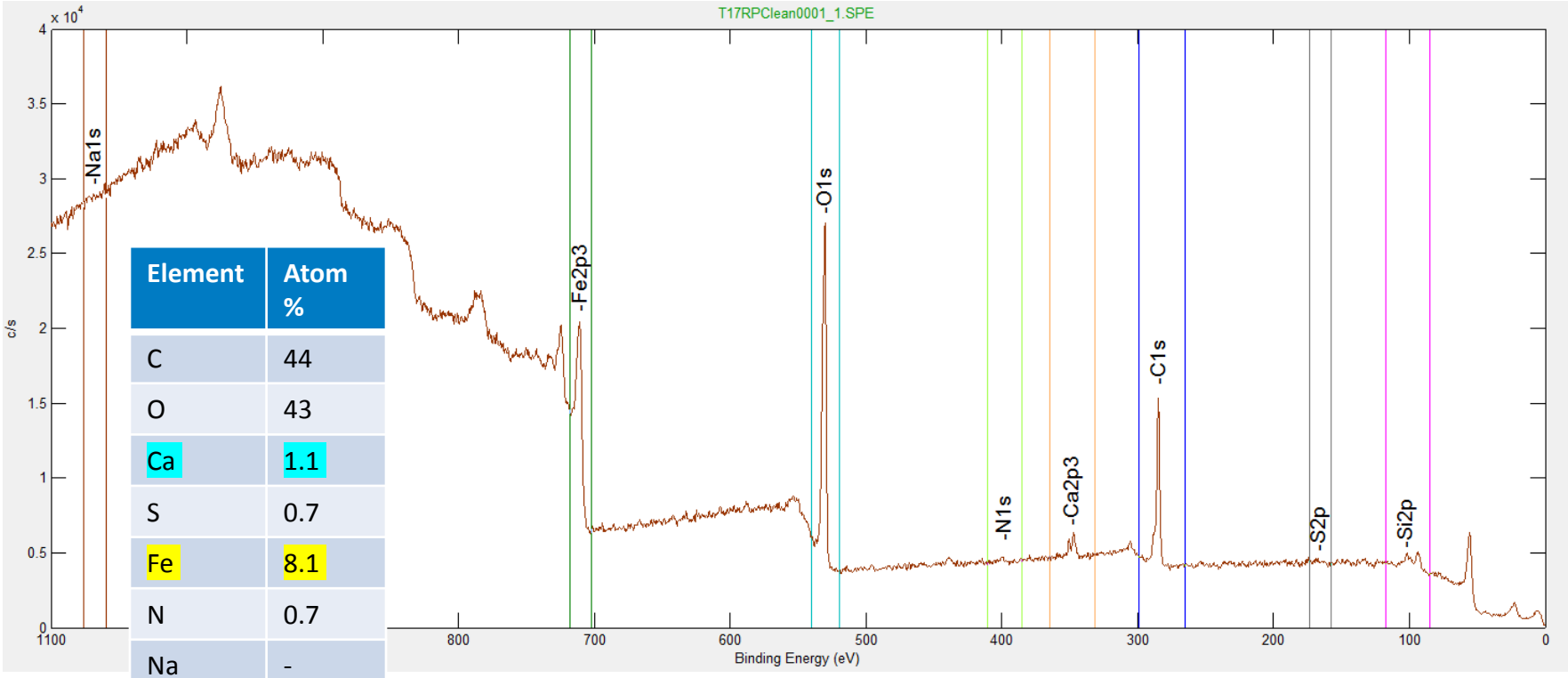
Element	Atom %
C	60
O	32
Ca	0.1
S	-
Fe	6.7
N	0.4
Na	0.9
Si	-

Results for C13 Liner samples – Lubrizol cleaned with Tide + rinsed in hexane



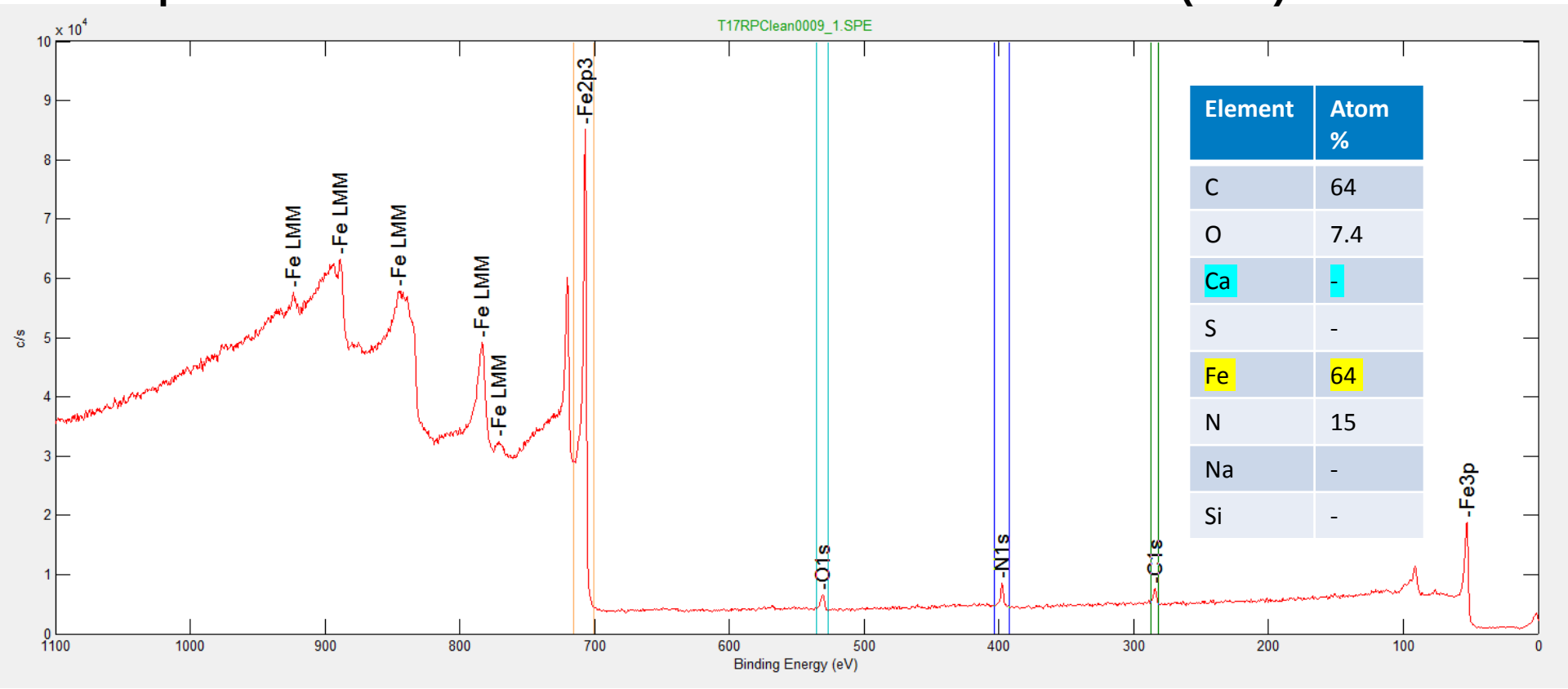
Element	Atom %
C	61
O	31
Ca	1.2
S	1.0
Fe	4.4
N	0.4
Na	0.2
Si	0.6

Results for C13 Liner samples
– Lubrizol cleaned with Tide + rinsed in hexane + wiped with isopropanol



Element	Atom %
C	44
O	43
Ca	1.1
S	0.7
Fe	8.1
N	0.7
Na	-
Si	1.7

Results for C13 Liner samples – Lubrizol cleaned with Tide + rinsed in hexane + wiped with isopropanol + ion sputtered in vacuum with Ar ions at 3.5keV for 1 minute (6nm)



Element	Atom %
C	64
O	7.4
Ca	-
S	-
Fe	64
N	15
Na	-
Si	-

Conclusions

- Iron from the substrate was visible on most samples before any cleaning process indicating that the Castrol Rustilo DW300 RP layer is thin (less than several atom layers) to start with.
- The CAT Control Sample C1 wiped with a rag resulted in partial removal of the RP layer and more exposure of the underlying iron substrate.
- The CAT sample L4 cleaned with LAC 147 left a significant layer of LAC 147 on the surface with no exposed substrate iron.
- The WD-40 cleaning method removed all of the RP.
- The Ensolv cleaning procedure also removed all but the slightest trace of RP and left the most iron exposed from the substrate liner.
- The Tide cleaning procedure left some Ca on the surface, but it's not clear whether the residual Ca was from the RP or the Tide.
- After rinsing the Tide cleaned sample with hexanes and isopropanol some Ca still remained on the surface.
- Sputtering the Tide cleaned sample with Ar ions to remove approximately 6nm (a dozen atom layers) resulted in the cleanest surface indicating that all of the contamination after cleaning is less than 6nm thick.