

Appendix F2

SEM/EDS Data for Test #4, Day-30 Copper Coupons

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This appendix shows the SEM/EDS results for the metal copper coupons under two categories: (1) unsubmerged and (2) submerged. Unsubmerged refers to coupons held in the test tank gas space above the water level of the solution during ICET. Unsubmerged coupons were contacted by the solution only during the 4-hour spraying period at the initial date of the test. In addition, the surface of the unsubmerged coupons may also be affected by the moisture in the gas space during the test. Submerged refers to the coupons that were under the solution during the test.

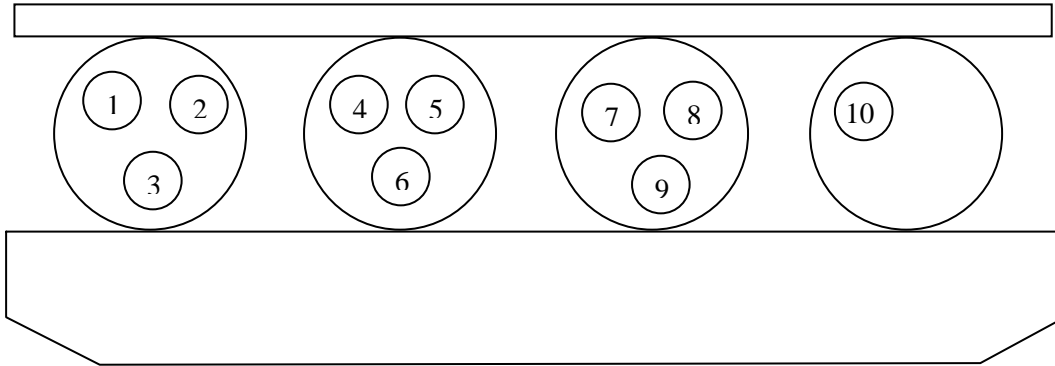
The coupon samples were collected on June 23, 2005 (the date Test #4 was shut down), and by SEM/EDS on June 29, 2005. The copper coupon samples were dried in air before being coated with Au/Pd for SEM examination. SEM results present the surface condition of the copper coupons. In addition, EDS results provide a semi-quantitative elemental analysis of the coupon surface and the corrosion products.

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Transcribed Laboratory Log

Laboratory session from June 29, 2005.
SEM Test #4, Day-30 Copper Coupons

- | | | | |
|-------------------|-------------------------|-------------------|---------------|
| 1. Unsubmerged Al | 3. Sus. Cu | 5. Sus. Gal Steel | 7. Sus. Steel |
| 2. Submerged Al | 4. Sub. Cu | 6. Sub. Gal Steel | 8. Sub. Steel |
| 9. Sediment | 10. Powder on Sub. Rack | | |



Unsubmerged Copper Coupon

Image:	T4D30CuSusp008	100 ×	SEM image	Figure F2-1
	T4D30CuSusp009	500 ×	SEM image higher magnification	Figure F2-2
	T4D30CuSusp010	1500 ×	SEM annotated image	Figure F2-3
EDS:	T4D30CuSusp05		On particles in T4D30CuSusp010	Figure F2-4

Submerged Copper Coupon

Image:	T4D30CuSubm011	100 ×	SEM image of fiberglass	Figure F2-5
	T4D30CuSubm012	500 ×	SEM image higher magnification	Figure F2-6
	T4D30CuSubm013	1800 ×	SEM annotated image	Figure F2-7
EDS:	T4D30CuSubm06		On bright particles shown in 013	Figure F2-8
	T4D30CuSubm07		Surface shown in 013	Figure F2-9

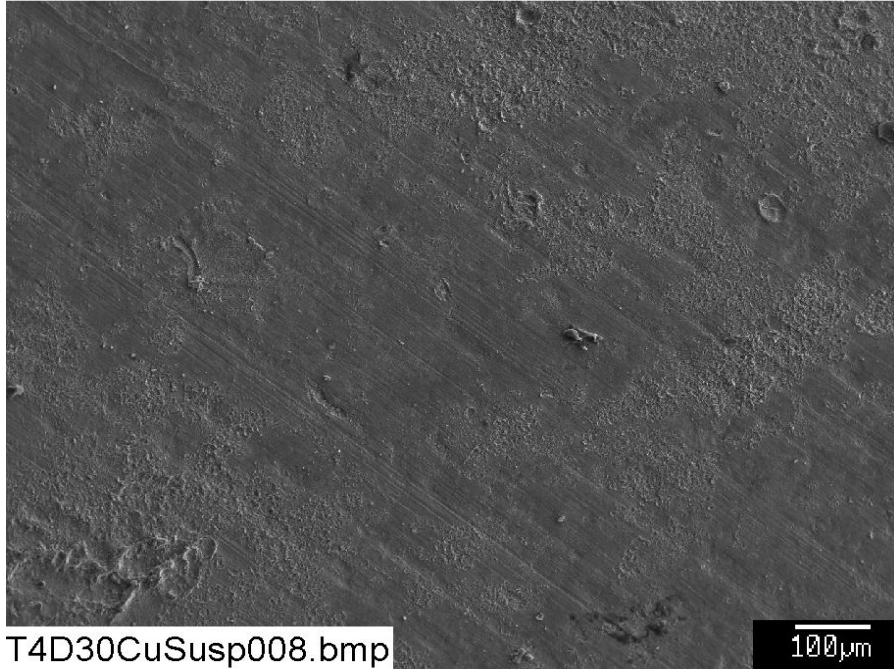


Figure F2-1. SEM image magnified 100 times for a Test #4, Day-30 unsubmerged copper coupon sample. (T4D30CuSusp008.bmp)

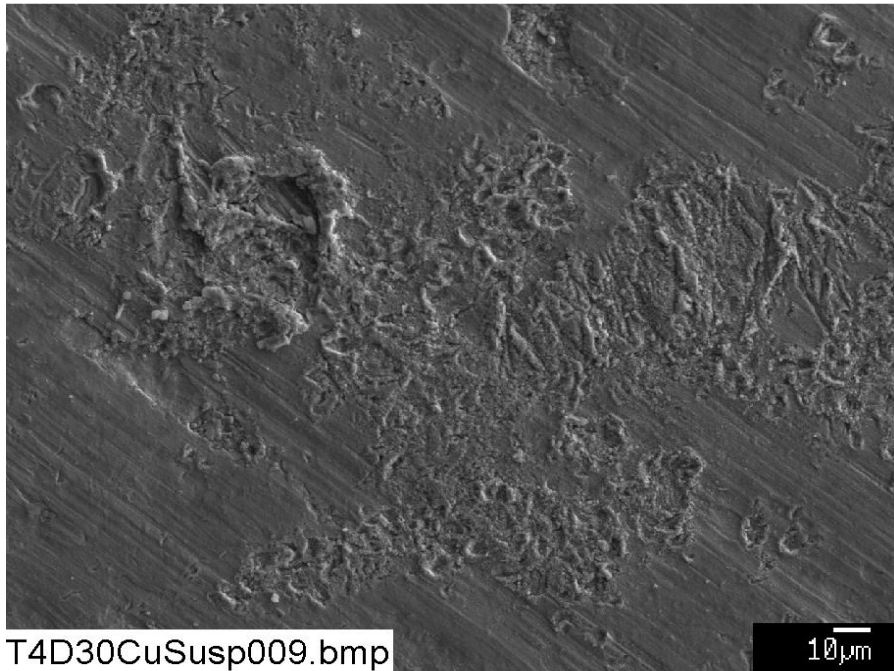


Figure F2-2. SEM image magnified 500 times for a Test #4, Day-30 unsubmerged copper coupon sample. (T4D30CuSusp009.bmp)

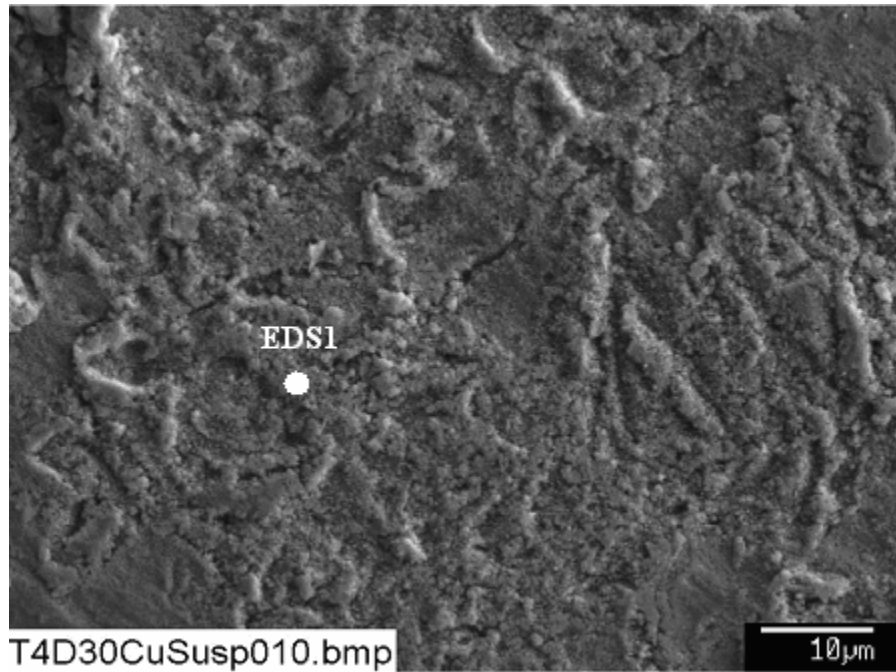


Figure F2-3. Annotated SEM image magnified 1500 times for a Test #4, Day-30 unsubmerged copper coupon sample. (T4D30CuSusp010.bmp)

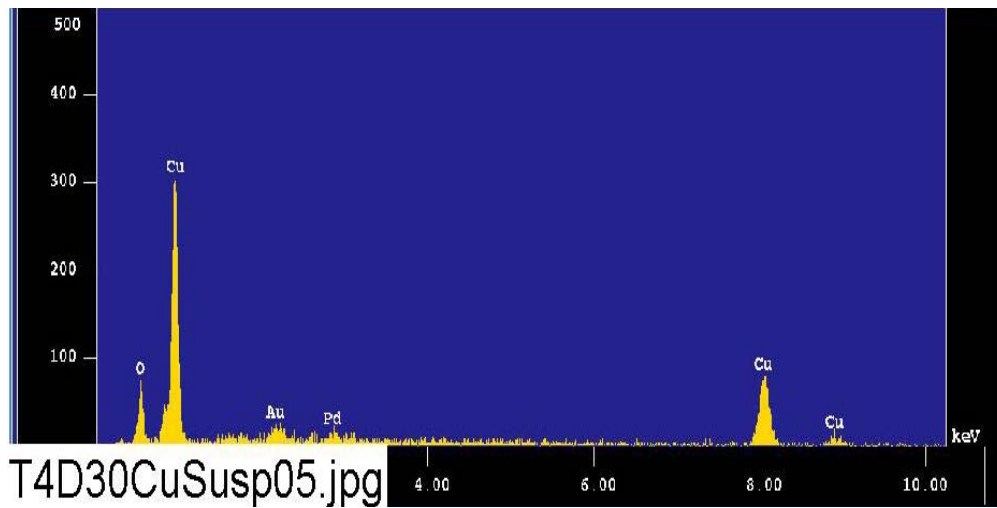


Figure F2-4. EDS counting spectrum for the deposits (EDS1) on the coupon surface shown in Figure F2-3. (T4D30CuSusp05.jpg)

The results from the chemical composition analysis for T4D30CuSusp05.jpg are given in Table F2-1.

Table F2-1. Chemical Compositions for T4D30CuSusp05.jpg, Figure F2-4

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```

Group      : NRC
Sample     : T4D30 ID# : 5
Comment    : particles on suspended Cu
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 60.000 sec   Aperture #   : 2
             Acc. Volt  : 15.0 KV      Probe Current : 1.065E-09 A
             Stage Point : X=81.233 Y=71.962 Z=10.786
             Acq. Date  : Wed Jun 29 13:41:34 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
O K	Normal	0.25- 0.77	16.7471	0.0012	554 / 13
Cu K	Normal	7.63- 9.27	105.3640	0.0057	1327 / 2

 Chi_square = 1.3920

Element	Mass%	Atomic%	ZAF	Z	A	F
O	11.102	33.1531	0.8154	0.8265	0.9868	0.9998
Cu	88.898	66.8469	1.0378	1.0386	0.9993	1.0000

 Total 100.000 100.0000
 Normalization factor = 0.8130

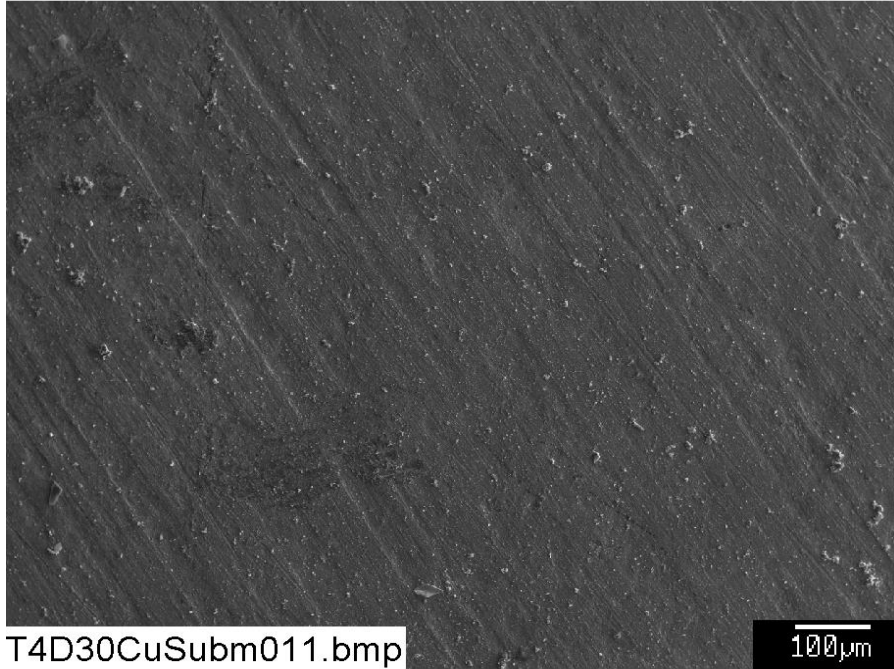


Figure F2-5. SEM image magnified 100 times for a Test #4, Day-30 submerged copper coupon sample. (T4D30CuSubm011.bmp)

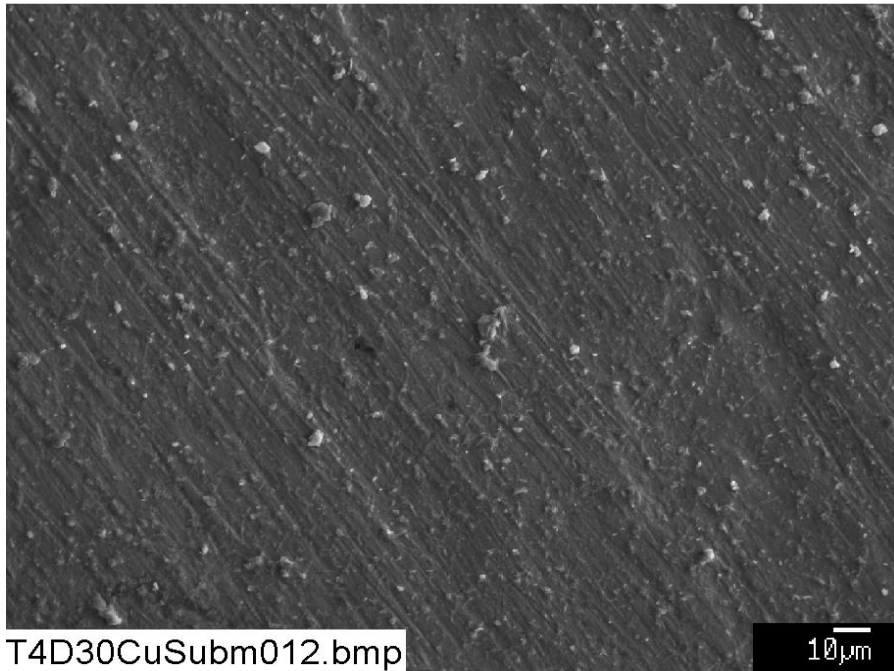


Figure F2-6. SEM image magnified 500 times for a Test #4, Day-30 submerged copper coupon sample. (T4D30CuSubm012.bmp)

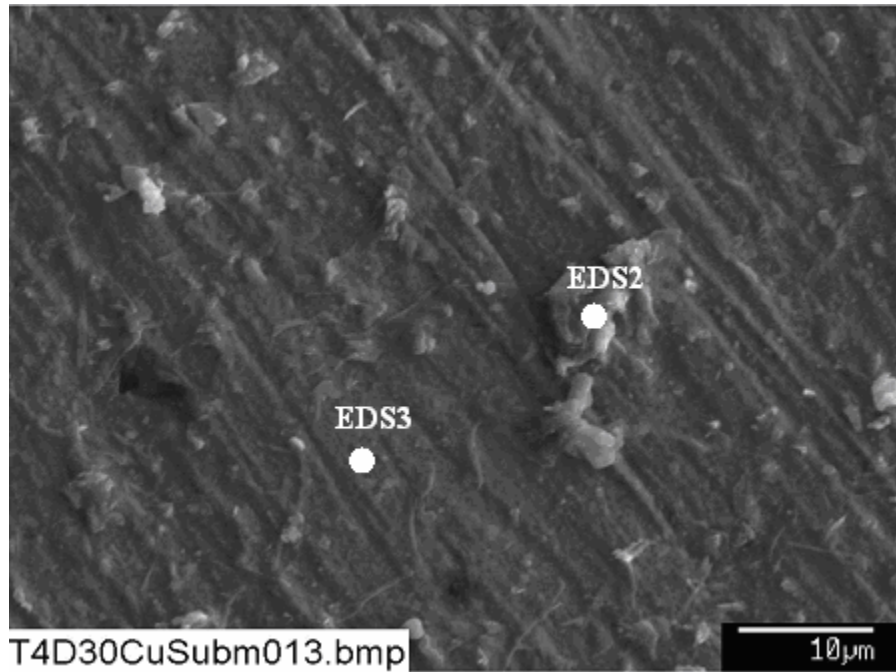


Figure F2-7. Annotated SEM image magnified 1800 times for a Test #4, Day-30 submerged copper coupon sample. (T4D30CuSubm013.bmp)

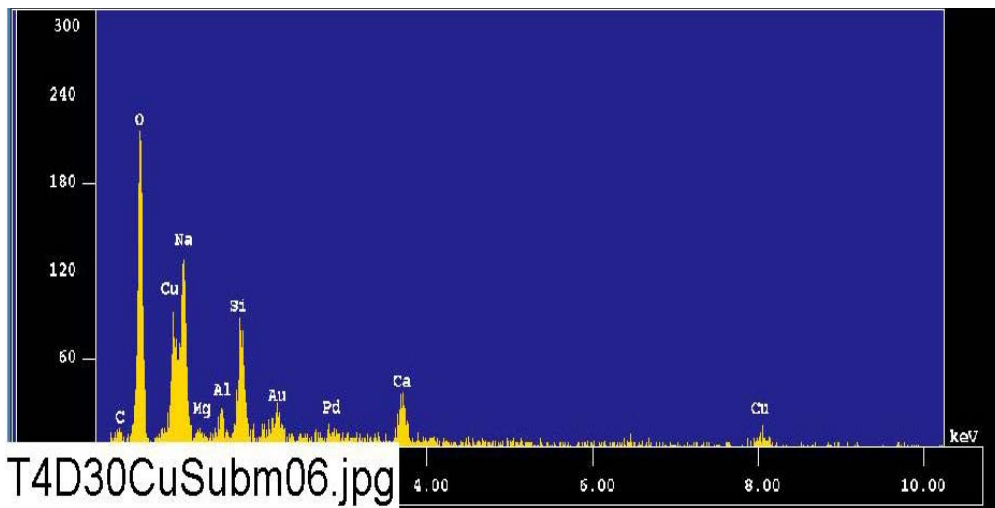


Figure F2-8. EDS counting spectrum for the deposit (EDS2) on the coupon surface shown in Figure F2-7. (T4D30CuSubm06.jpg)

The results from the chemical composition analysis for T4D30CuSubm06.jpg are given in Table F2-2.

Table F2-2. Chemical Compositions for T4D30CuSubm06.jpg, Figure F2-8

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```

Group       : NRC
Sample      : T4D30 ID# : 6
Comment     : light particles on submerged Cu
Condition   : Full Scale : 20KeV(10eV/ch,2Kch)
              Live Time  : 60.000 sec   Aperture #   : 2
              Acc. Volt  : 15.0 KV      Probe Current : 1.065E-09 A
              Stage Point: X=57.699 Y=58.376 Z=10.786
              Acq. Date  : Wed Jun 29 13:54:39 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background	
O K	Normal	0.25- 0.77	55.2961	0.0018	1829 /	10
Na K	Normal	0.81- 1.27	11.0827	0.0010	1053 /	13
Al K	Normal	1.26- 1.78	1.1553	0.0003	159 /	32
Si K	Normal	1.50- 2.07	4.0896	0.0005	523 /	17
Ca K	Normal	3.40- 4.30	4.2931	0.0035	267 /	6
Cu K	Normal	7.63- 9.27	9.7062	0.0023	122 /	2
C K	Normal	0.09- 0.46	0.0000	0.0000	0 /	16
Mg K	Normal	0.97- 1.57	0.0718	0.0001	10 /	36

Chi_square = 2.6388

Element	Mass%	Atomic%	ZAF	Z	A	F
O	52.039	67.6839	0.8346	0.9692	0.8612	0.9999
Na	20.992	19.0006	1.6798	1.0227	1.6423	1.0001
Al	1.925	1.4848	1.4779	0.9846	1.5028	0.9988
Si	6.377	4.7251	1.3829	0.9729	1.4216	0.9999
Ca	4.710	2.4453	0.9729	0.9809	0.9925	0.9994
Cu	13.788	4.5154	1.2597	1.2639	0.9967	1.0000
C	0.000	0.0000	4.0970	1.0163	4.0314	0.9999
Mg	0.169	0.1449	2.0917	0.9627	2.1740	0.9994

Total 100.000 100.0000
 Normalization factor = 1.1276

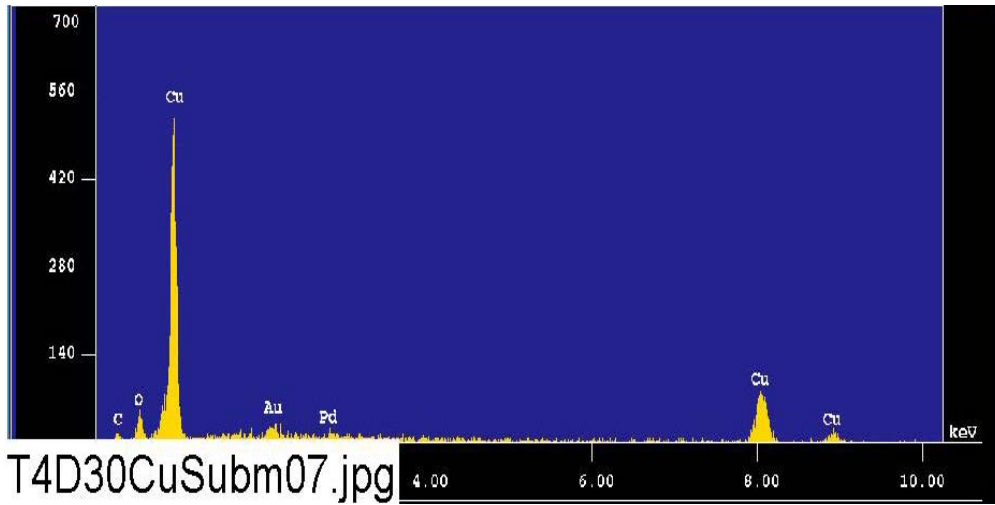


Figure F2-9. EDS counting spectrum for the flat coupon surface (EDS3) shown in Figure F2-7. (T4D30CuSubm07.jpg)

The results from the chemical composition analysis for T4D30CuSubm07.jpg are given in Table F2-3.

Table F2-3. Chemical Compositions for T4D30CuSubm07.jpg, Figure F2-9

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```

Group       : NRC
Sample      : T4D30 ID# : 7
Comment     : surface of submerged Cu
Condition   : Full Scale : 20KeV(10eV/ch,2Kch)
              Live Time  : 60.000 sec   Aperture #   : 2
              Acc. Volt  : 15.0 KV      Probe Current : 1.065E-09 A
              Stage Point : X=57.699 Y=58.376 Z=10.786
              Acq. Date  : Wed Jun 29 13:59:37 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
O K	Normal	0.25- 0.77	12.2183	0.0011	404 / 21
Cu K	Normal	7.63- 9.27	113.6477	0.0061	1432 / 0
C K	Normal	0.09- 0.46	2.1513	0.0001	106 / 4

Chi_square = 0.9631

Element	Mass%	Atomic%	ZAF	Z	A	F
O	7.923	20.9480	0.8970	0.8301	1.0807	0.9998
Cu	85.861	57.1606	1.0450	1.0460	0.9991	1.0000
C	6.216	21.8914	3.9968	0.8712	4.5876	1.0000

Total 100.000 100.0000
 Normalization factor = 0.7229

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Appendix F3

SEM/EDS Data for Test #4, Day-30 Galvanized Steel Coupons

Figures

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Table F3-3.	Chemical Compositions for T4D30GalSubm11.jpg, Figure F3-10.....	F3-11

This appendix shows the SEM/EDS results for the metal galvanized steel coupons under two categories: (1) unsubmerged and (2) submerged. Unsubmerged refers to coupons held in the test tank gas space above the water level of the solution during ICET. Unsubmerged coupons were contacted by the solution only during the 4-hour spraying period at the initial date of the test. In addition, the surface of the unsubmerged coupons may also be affected by the moisture in the gas space during the test. Submerged refers to the coupons that were under the solution during the test.

The coupon samples were collected on June 23, 2005 (the date Test #4 was shut down), and examined by SEM/EDS on June 29, 2005. The galvanized steel coupon samples were dried in air before being coated with Au/Pd for SEM examination. SEM results present the surface condition of the galvanized steel coupons. In addition, EDS results provide a semi-quantitative elemental analysis of the coupon surface and the corrosion products.

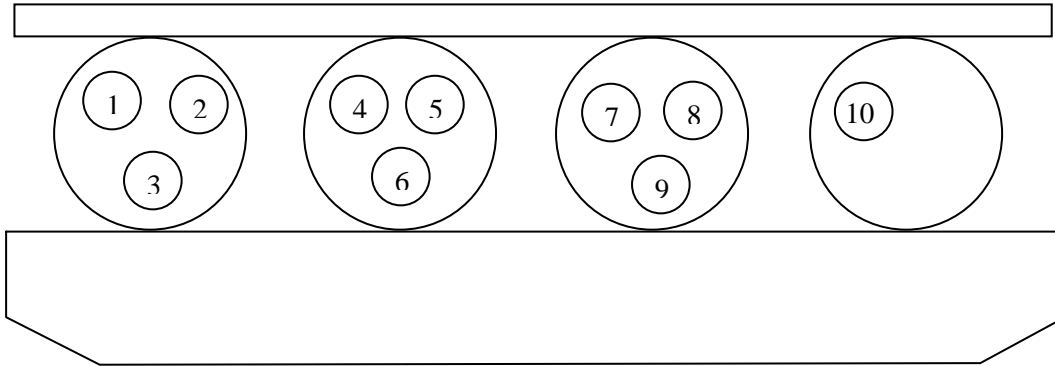
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Transcribed Laboratory Log

Laboratory session from June 29, 2005.

SEM Test #4, Day-30 Galvanized Steel Coupons

- | | | | |
|-------------------|-------------------------|-------------------|---------------|
| 1. Unsubmerged Al | 3. Sus. Cu | 5. Sus. Gal Steel | 7. Sus. Steel |
| 2. Submerged Al | 4. Sub. Cu | 6. Sub. Gal Steel | 8. Sub. Steel |
| 9. Sediment | 10. Powder on Sub. Rack | | |



Unsubmerged Galvanized Steel Coupon

Image:	T4D30GalSusp014	100 ×	SEM image	Figure F3-1
	T4D30GalSusp015	500 ×	SEM image	Figure F3-2
	T4D30GalSusp016	1800 ×	SEM annotated image	Figure F3-3
EDS:	T4D30GalSusp08		Particles shown in 016	Figure F3-4
	T4D30Galsusp09		Surface shown in 016	Figure F3-5

Submerged Galvanized Steel Coupon

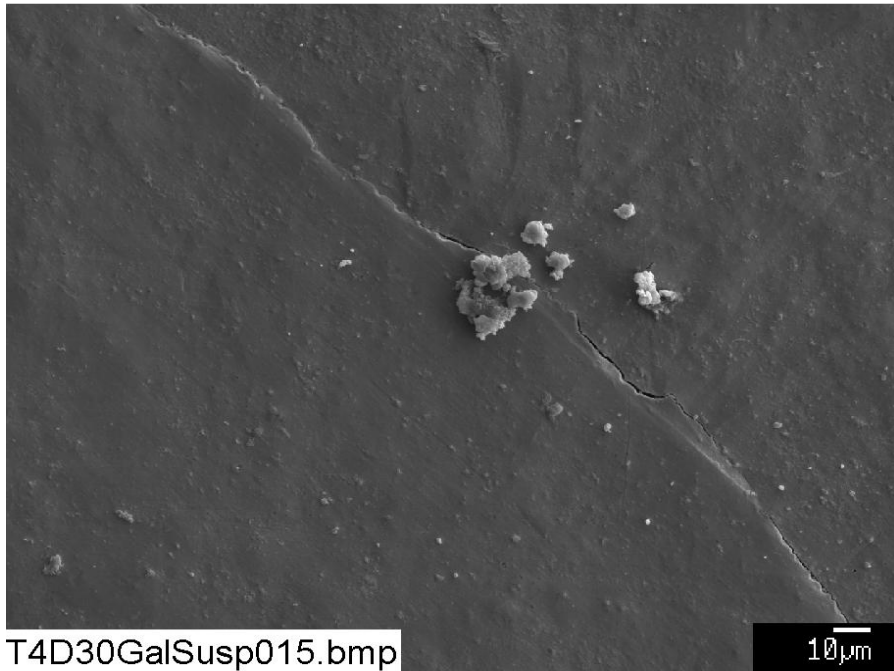
Image:	T4D30GalSubm017	100 ×	SEM image	Figure F3-6
	T4D30GalSubm018	500 ×	SEM image	Figure F3-7
	T4D30GalSubm019	1800 ×	SEM annotated image	Figure F3-8
	T4D30GalSubm10		Particles shown in 019	Figure F3-9
	T4D30GalSubm11		Surface shown in 019	Figure F3-10



T4D30GalSusp014.bmp

100 μm

Figure F3-1. SEM image magnified 100 times for a Test #4, Day-30 unsubmerged galvanized steel coupon sample. (T4D30GalSusp014.bmp)



T4D30GalSusp015.bmp

10 μm

Figure F3-2. SEM image magnified 500 times for a Test #4, Day-30 unsubmerged galvanized steel coupon sample. (T4D30GalSusp015.bmp)

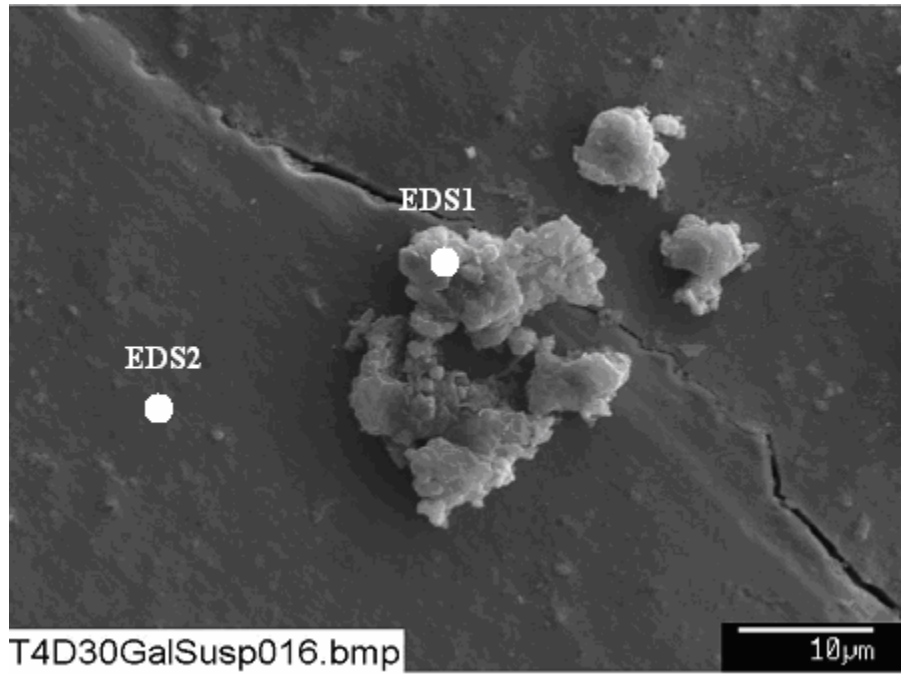


Figure F3-3. Annotated SEM image magnified 1800 times for a Test #4, Day-30 unsubmerged galvanneal steel coupon sample. (T4D30GalSusp016.bmp)

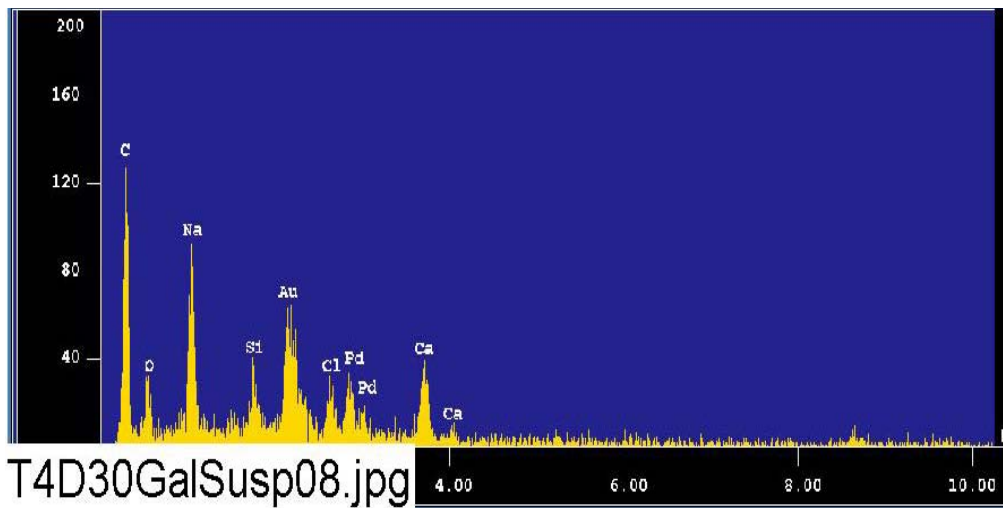


Figure F3-4. EDS counting spectrum for the deposits (EDS1) on the coupon surface shown in Figure F3-3. (T4D30GalSusp08.jpg)

The results from the chemical composition analysis for T4D30GalSusp08.jpg are given in Table F3-1.

Table F3-1. Chemical Compositions for T4D30GalSusp08.jpg, Figure F3-4

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```

Group       : NRC
Sample      : T4D30 ID# : 8
Comment     : particle on suspended Gal-steel
Condition   : Full Scale : 20KeV(10eV/ch,2Kch)
              Live Time  : 60.000 sec   Aperture #   : 2
              Acc. Volt  : 15.0 KV      Probe Current : 1.064E-09 A
              Stage Point : X=44.143 Y=59.814 Z=10.786
              Acq. Date  : Wed Jun 29 14:12:20 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
C K	Normal	0.09- 0.46	17.7108	0.0003	868 / 7
O K	Normal	0.25- 0.77	7.9933	0.0009	264 / 43
Na K	Normal	0.81- 1.27	4.1179	0.0007	391 / 7
Si K	Normal	1.50- 2.07	1.2113	0.0004	155 / 14
Cl K	Normal	2.34- 3.06	3.7051	0.0005	324 / 14
Ca K	Normal	3.40- 4.30	5.1818	0.0037	322 / 5

 Chi_square = 6.7756

Element	Mass%	Atomic%	ZAF	Z	A	F
C	57.624	69.8633	2.4583	1.0116	2.4303	1.0000
O	22.840	20.7886	2.1589	0.9652	2.2368	1.0000
Na	6.485	4.1080	1.1900	1.0197	1.1668	1.0002
Si	1.750	0.9073	1.0916	0.9716	1.1247	0.9989
Cl	4.786	1.9657	0.9759	1.0255	0.9552	0.9963
Ca	6.515	2.3671	0.9500	0.9837	0.9657	1.0001

 Total 100.000 100.0000
 Normalization factor = 1.3235

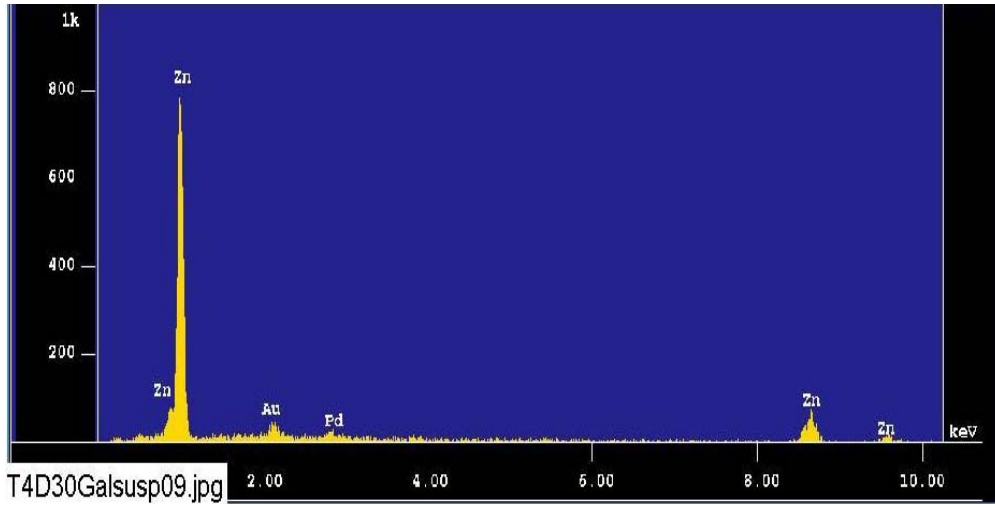


Figure F3-5. EDS counting spectrum for the flat coupon surface (EDS2) shown in Figure F3-3. (T4D30Galsusp09.jpg)

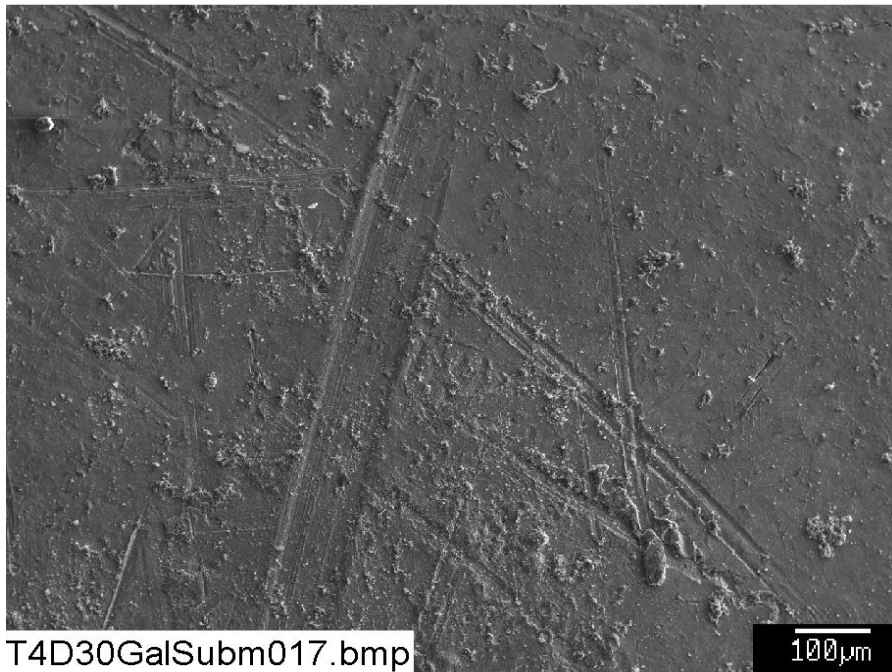


Figure F3-6. SEM image magnified 100 times for a Test #4, Day-30 submerged galvanized steel coupon sample. (T4D30GalSubm017.bmp)

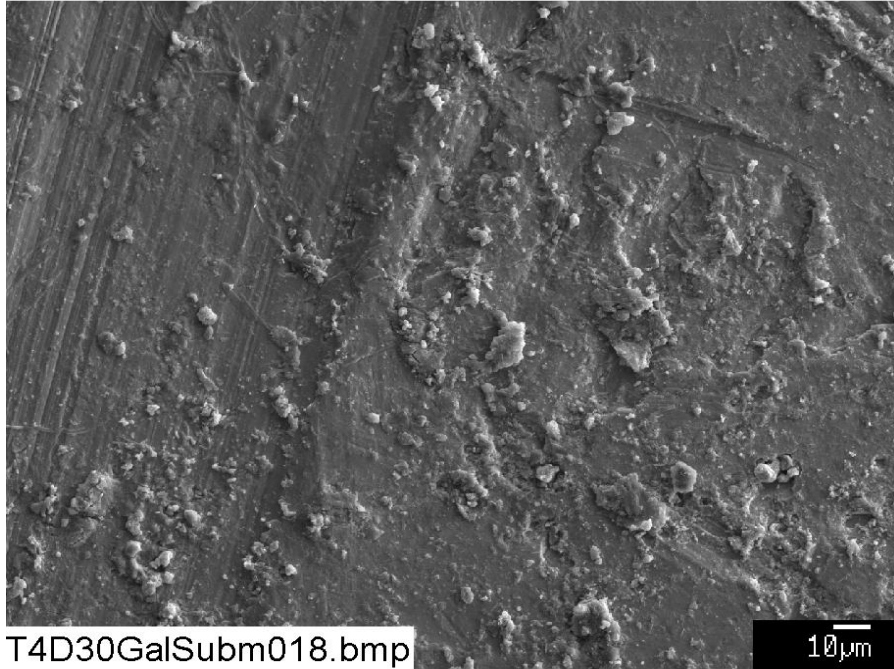


Figure F3-7. SEM image magnified 500 times for a Test #4, Day-30 submerged galvanized steel coupon sample. (T4D30GalSubm018.bmp)

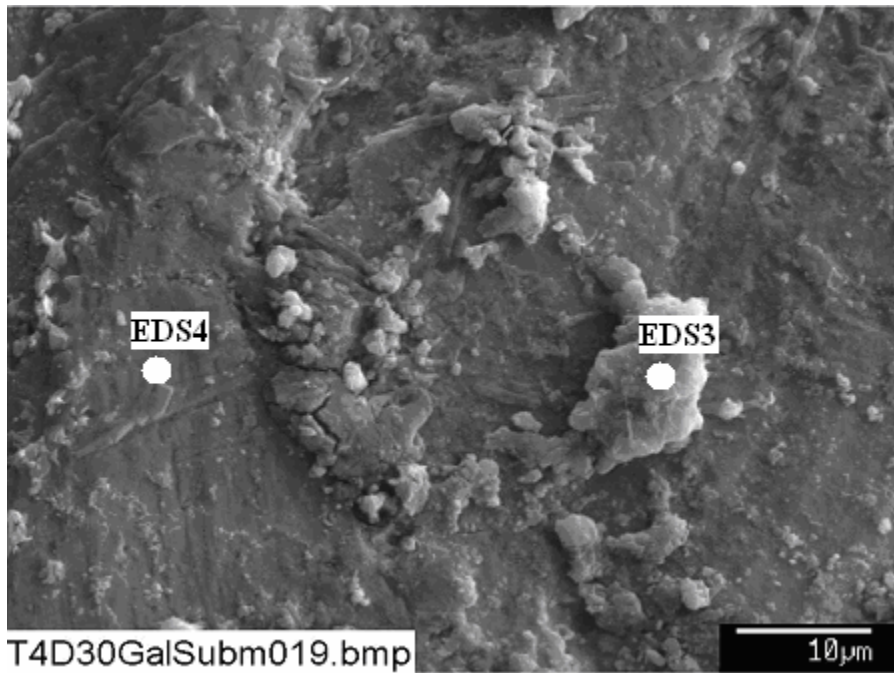


Figure F3-8. Annotated SEM image magnified 1800 times for a Test #4, Day-30 submerged galvanized steel coupon sample. (T4D30GalSubm019.bmp)

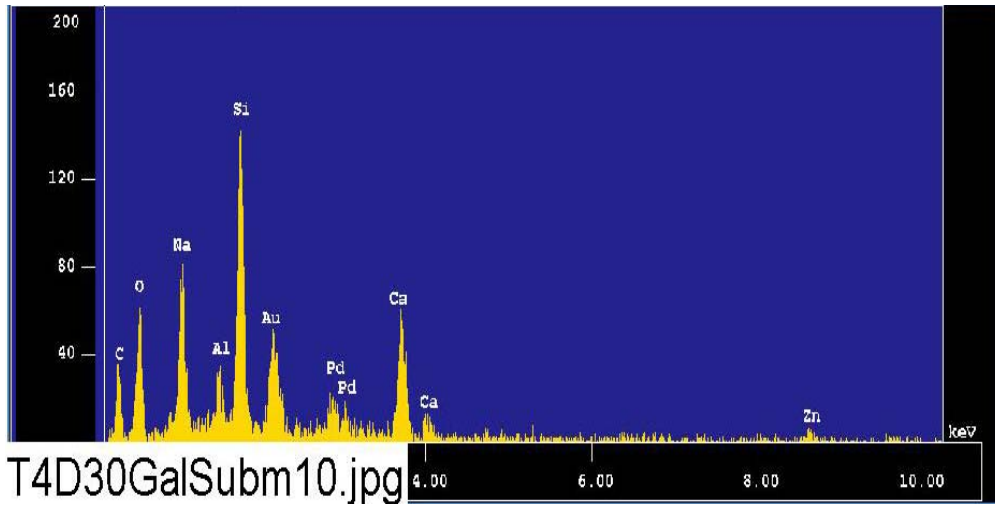


Figure F3-9. EDS counting spectrum for the deposits (EDS3) on the coupon surface shown in Figure F3-8. (T4D30GalSubm10.jpg)

The results from the chemical composition analysis for T4D30GalSubm10.jpg are given in Table F3-2.

Table F3-2. Chemical Compositions for T4D30GalSubm10.jpg, Figure F3-9

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```

Group       : NRC
Sample      : T4D30 ID# : 10
Comment     : Particle on submerged Gal-steel
Condition   : Full Scale : 20KeV(10eV/ch,2Kch)
              Live Time  : 60.000 sec   Aperture #   : 2
              Acc. Volt  : 15.0 KV      Probe Current : 1.067E-09 A
              Stage Point : X=50.108 Y=68.926 Z=10.786
              Acq. Date  : Wed Jun 29 14:30:34 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background	
C K	Normal	0.09- 0.46	4.3159	0.0001	212 /	6
O K	Normal	0.25- 0.77	17.0145	0.0011	564 /	10
Na K	Normal	0.81- 1.27	6.3047	0.0007	600 /	6
Al K	Normal	1.26- 1.78	1.7139	0.0004	236 /	56
Si K	Normal	1.50- 2.07	7.1958	0.0006	923 /	25
Ca K	Normal	3.40- 4.30	8.1648	0.0042	509 /	2

Chi_square = 2.5440

Element	Mass%	Atomic%	ZAF	Z	A	F
C	23.363	34.2953	3.7436	1.0268	3.6461	1.0000
O	38.077	41.9614	1.5476	0.9794	1.5802	1.0000
Na	11.659	8.9415	1.2789	1.0340	1.2371	0.9998
Al	2.933	1.9165	1.1835	0.9960	1.1924	0.9965
Si	12.465	7.8251	1.1980	0.9844	1.2173	0.9997
Ca	11.503	5.0602	0.9743	0.9944	0.9797	1.0001

Total 100.000 100.0000
Normalization factor = 1.4460

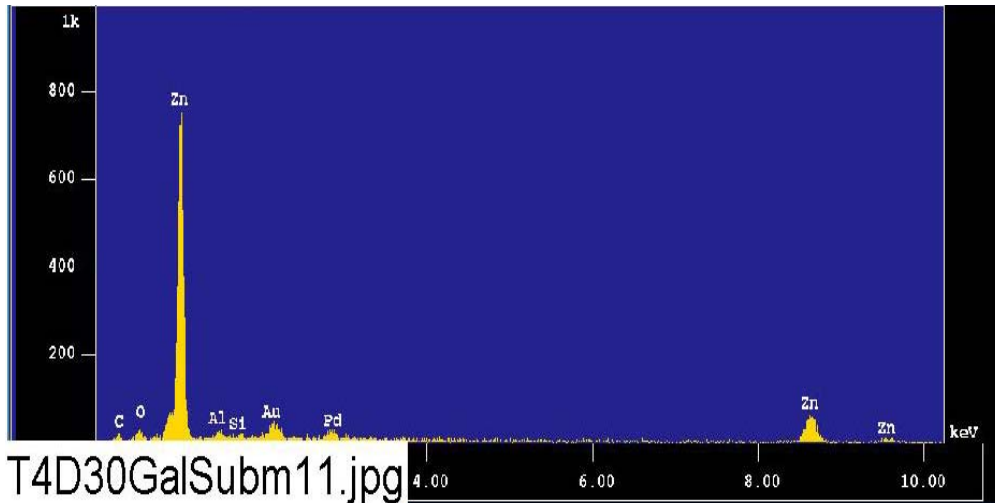


Figure F3-10. EDS counting spectrum for the flat coupon surface (EDS4) shown in Figure F3-8. (T4D30GalSubm11.jpg)

The results from the chemical composition analysis for T4D30GalSubm11.jpg are given in Table F3-3

Table F3-3. Chemical Compositions for T4D30GalSubm11.jpg, Figure F3-10

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```

Group      : NRC
Sample     : T4D30 ID# : 11
Comment    : Surface of submerged Gal-steel
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
Live Time  : 60.000 sec  Aperture # : 2
Acc. Volt  : 15.0 KV     Probe Current : 1.066E-09 A
Stage Point : X=50.108 Y=68.926 Z=10.786
Acq. Date  : Wed Jun 29 14:35:16 2005
  
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background	
O K	Normal	0.25- 0.77	7.3244	0.0010	243 /	18
Al K	Normal	1.26- 1.78	0.9436	0.0004	130 /	16
Si K	Normal	1.50- 2.07	0.4713	0.0003	60 /	22
Zn K	Normal	8.22-10.03	118.8961	0.0077	1137 /	2
C K	Normal	0.09- 0.46	2.8301	0.0001	139 /	2

Chi_square = 0.5995

Element	Mass%	Atomic%	ZAF	Z	A	F
O	4.987	12.5657	1.0235	0.8341	1.2272	0.9999
Al	1.235	1.8457	1.9679	0.8447	2.3300	0.9999
Si	0.520	0.7459	1.6575	0.8339	1.9877	1.0000
Zn	83.279	51.3537	1.0528	1.0538	0.9991	1.0000
C	9.979	33.4891	5.2998	0.8754	6.0542	1.0000

Total 100.000 100.0000
 Normalization factor = 0.6653

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