Ionic Analysis of Common Beverages Spilled on Electronics

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EXECUTIVE SUMMARY

Electronics, especially mobile electronic items, are subjected to unintentional abuse by having various beverages spilled onto or into them. Ion Chromatography and emission spectroscopy were used to identify the common inorganic ions in various carbonated drinks, coffee, tea, milk, juices, beer, wine, hot chocolate and a well-known sports drink. Except for the carbonated drinks, the others were then intentionally spilled onto clean circuit boards, dried, extracted and re-analyzed. The results show that there is generally little change from the virgin materials using the IPC extraction method and thus a library of "usual suspects" can be accumulated for comparison purposes for electronic products that come back from the field.

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Continuation of what I showed you last time

- **Coca-Cola™**
- **Pepsi Cola™**
- **Dr. Pepper™**
- **Sprite™**
- **Barq’s Root Beer™**
- **Canada Dry Ginger Ale™**
- Starbuck’s™ Coffee
- Red Rose™ Tea
- Minute Maid™ Apple Juice
- Tropicana™ Orange Juice
- Heinz™ Tomato Juice
- Wolf Blass™ Wine
- Alexander Keith’s India Pale Ale™ (beer)
- Nestle Carnation™ Instant Hot Chocolate
- Gatorade™ Sports Drink
- Milk (2%)

IC

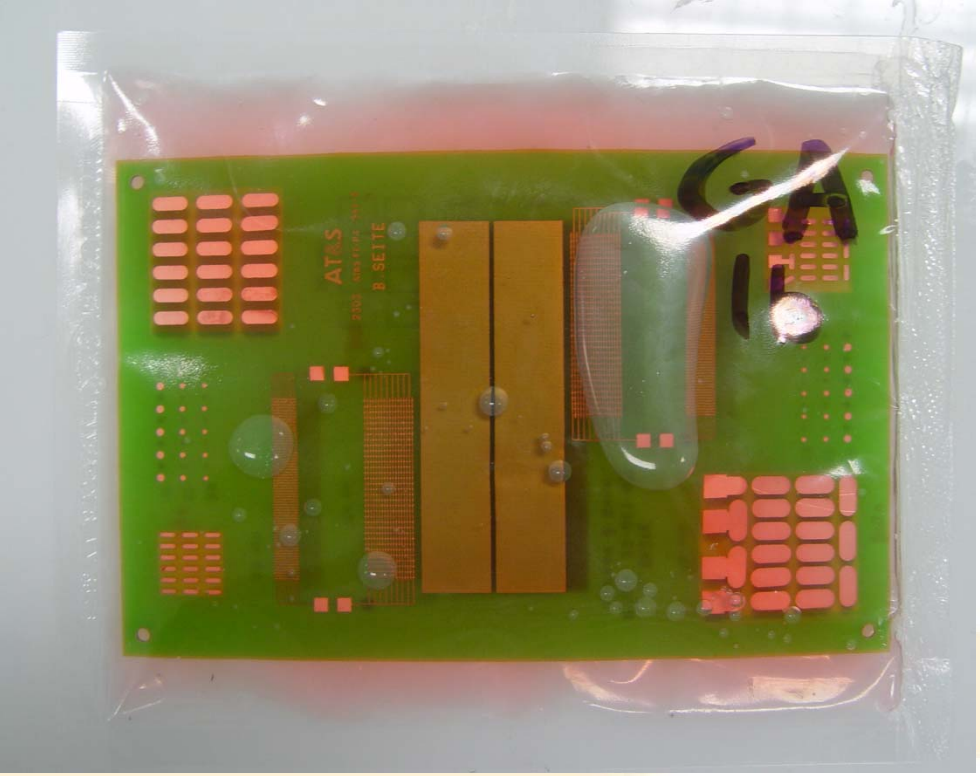
- Dionex GP40 gradient pump
- coupled with a CD20 conductivity detector
- Dionex ASRS-ULTRA II 4mm suppressor
- Stationary phase was an IonPac AS14A 4X250mm Dionex column equipped with an AG14A guard.
- Aqueous 8mM Na_2CO_3/1mM $NaHCO_3$ mobile phase
- A three point linear calibration was used to calibrate the system with 1, 5, and 10ppm standard solutions.
- 34.5µL of each sample was injected and run isocratically through the chromatagraph for up to twelve minutes.
- Each sample batch was run between sets of three reference standards at 1, 5 and 10 ppm concentration.
- Samples were first analyzed at 100X dilutions and were further concentrated as necessary to resolve those analytes present in lower concentrations.

ICP-OES

- **Perkin Elmer Optima 3000DV ICP with optical emissions detection.**
- **Samples were prepared in a 2% nitric acid aqueous medium at 10, 100 and 1000X dilutions.**
- **A two point calibration was done with these standards at 1ppm and 10ppm for Ca, Mg, Na, and K; iron was present in these standards at 0.1ppm and 1ppm concentrations.**
- **A single verification standard was also run along with the samples at the middle point of 0.5ppm for Fe and 5ppm for the other cations**

Samples Also dried onto PCBs

- Single-sided 11x17 cm FR4 PCBs
- Five milliliters of each sample was spilled on individual PCBs using a volumetric pipettor to evenly distribute the contaminant across their surface
- Each board was then baked at 50°C for 12 hours
- After drying, the contamination was extracted using the IPC standard test method for ionic analysis of circuit boards.
- Each board was placed in a heat sealable 500 series KAPAK® bag
- Before sealing, 100mL of 60/40 IPA/H_2O extraction solution was added to each bag. The sealed bags were then immersed in an 80°C water bath for one hour to extract all surface contamination into solution.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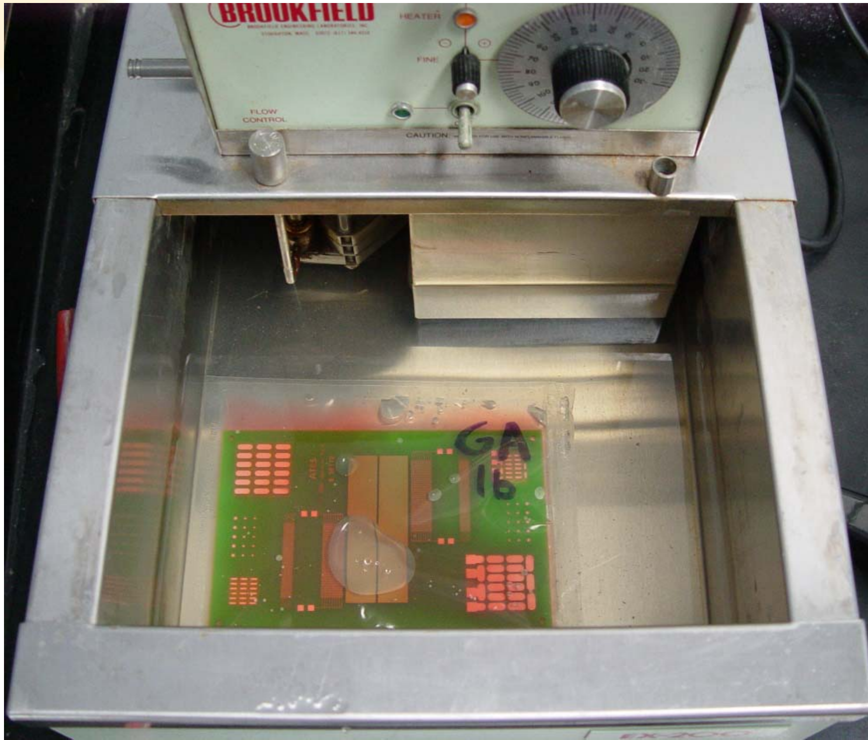
BROOKFIELD
HEATER
FINE
FLOW CONTROL
CAUTION
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Sample Prep

- **Following this extraction, 10mL of solution from each bag was decanted into 15mL tubes.**
- **IPA was removed from the solutions by drying. Drying was achieved using a VWR standard heating block with clean, dry air blown across samples. Each 10mL sample was dried down to 1mL and then diluted back to 10mL with Milli-Q water.**
- **Drying was repeated to 1mL after which the solutions were again brought to 10mL with Milli-Q water.**
- **IPA removal is necessary in order to produce a stable baseline as well as to ensure that samples are in the same solvent mix as reference and calibration standards.**

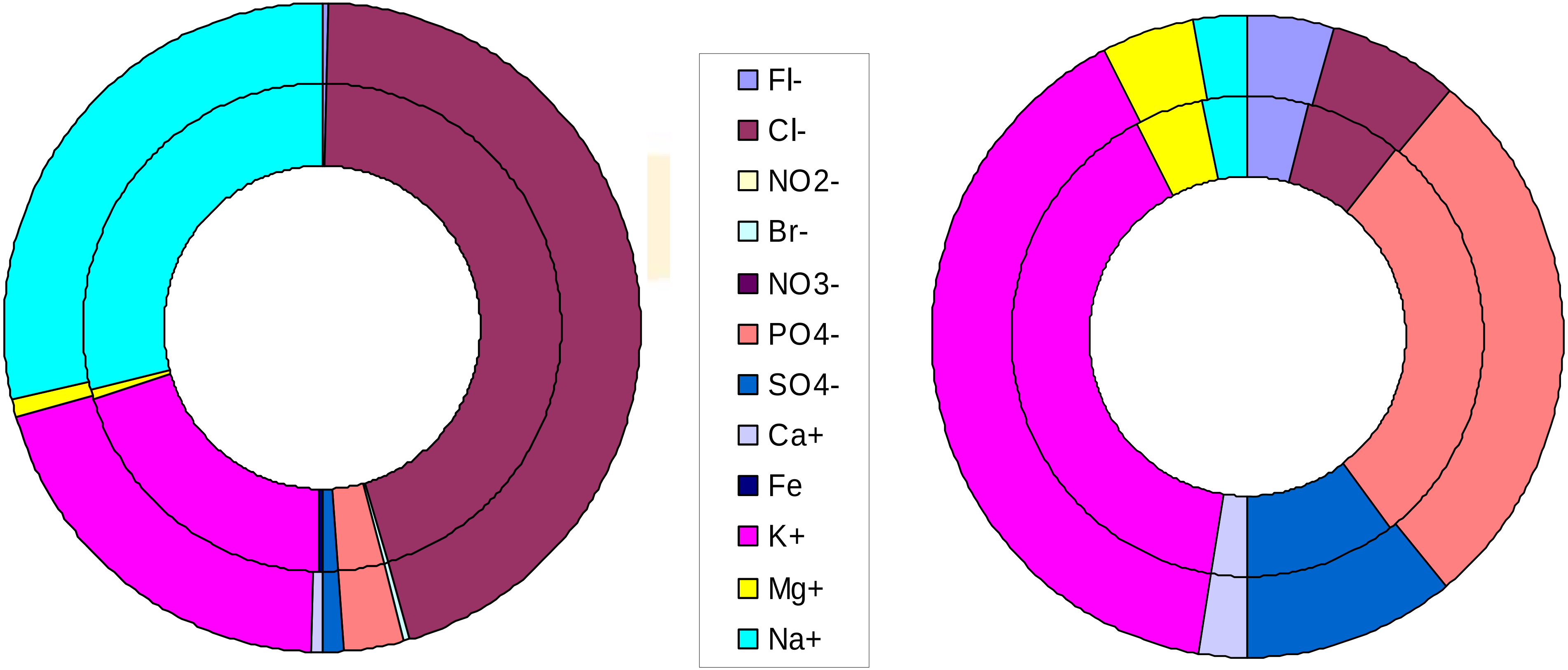
Reproducibility

	F^-	Cl^-	NO_2^-	Br^-	NO_3^-	PO_4^{-3}	SO_4^{-2}
Apple juice 1	165	81.5	0	0	0	3410	3.08
Apple juice 2	151	55.5	0	0	0	3350	3.01
Tomato juice 1	37	6920	0	45	0	446	151
Tomato juice 2	45	7260	0	46	0	542	166

Reproducibility

	Ca^{+2}	K^{+}	Mg^{+2}	Na^{+}	Fe^{+x}
Apple juice 1	66.4	1080	45.6	4980	0.888
Apple juice 2	66.0	1070	45.3	4840	0.867
Tomato juice 1	45.8	1920	79.0	2740	15.8
Tomato juice 2	49.3	2000	84.9	2880	17.2

Charts of relative ion concentrations calculated for tomato juice (left) and wine (right) from Part One results (outside) and Part Two results (inside).



Example of Identification Scheme

Apple juice, beer, coffee, Gatorade, hot chocolate, milk, orange juice, tea, tomato juice and wine
|
| **$F^-/Cl^- > 6$ → Coffee**
V
|
| **$Na^+/K^+ > 3$ → Gatorade**
V
|
| **$F^-/Cl^- > 2 - 3$ → Apple Juice & Tea SO_4^{2-}/PO_4^{3-} of Tea ~10X of Apple Juice**
V
|
| **$Na^+/K^+ > 1 - 2$ → Hot chocolate & Tomato Juice SO_4^{2-}/PO_4^{3-} of Tomato Juice ~6X of Hot Chocolate**
V
|
| **$F^-/Cl^- > 0.5 - 1$ → Orange Juice & Wine SO_4^{2-}/PO_4^{3-} of Wine ~7X of Orange Juice**
V
Beer and Milk $(SO_4^{2-}/PO_4^{3-})/(Na^+/K^+) \sim 3$ → Beer
|
|
V
Milk