Apr 26th, 2:30 PM - 2:45 PM

Monitoring BPA Leaching from Feminine Hygiene Products using Fluorescence Spectrophotometry

Madison Easley
Ouachita Baptist University

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MADISON EASLEY

OUACHITA BAPTIST UNIVERSITY
J.D. Patterson School of Natural Sciences

Bisphenol-A (BPA)

1891

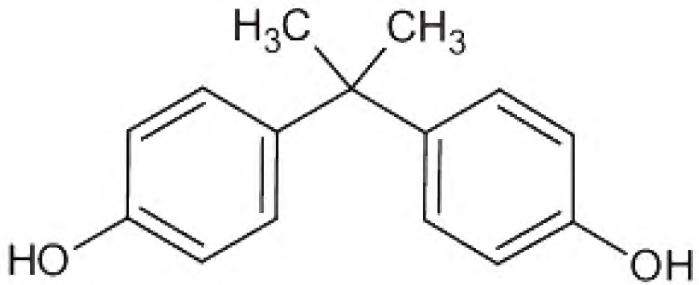
SYNTHESIZED

1950’s

INDUSTRIAL USE IN PLASTICS

2004

93% OF AMERICANS 6+ YEARS OF AGE HAVE BPA IN URINE



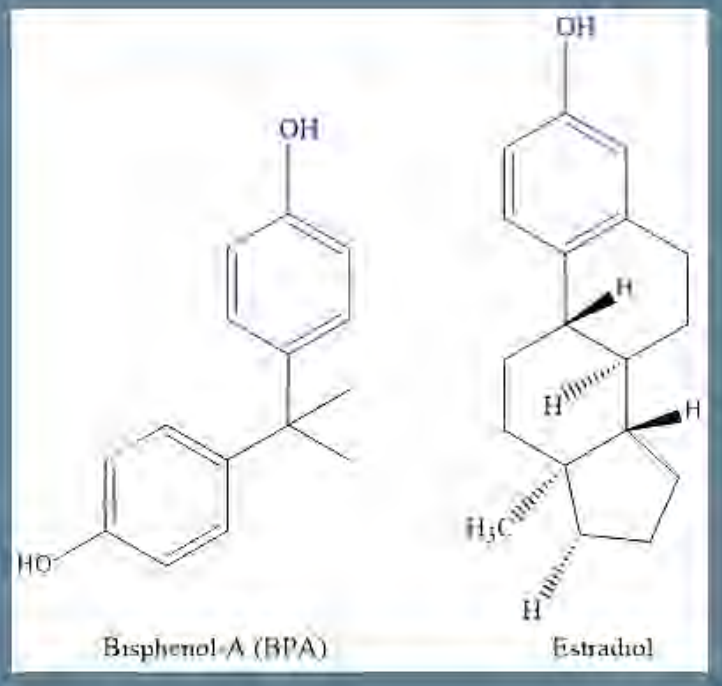
Bisphenol-A

Legeay, S. (2017). *Molecular structure of BPA*. ResearchGate. Retrieved April 21, 2023, from https://www.researchgate.net/figure/Molecular-structure-of-BPA_fig1_317650049

Xu, S.-Y., & Zuang, H. (2011). Leaching behaviour of bisphenol A from municipal solid waste under landfill environment. *National Library of Medicine*, *32*, 1269-77. PubMed. 10.1080/09593330.2010.535175

Genuis, S. (2012). Human Excretion of Bisphenol A: Blood, Urine, and Sweat (BUS) Study. *National Library of Medicine*, *2012*, 185731. PubMed. 10.1155/2012/185731

ENDOCRINE DISRUPTOR



Ludwicka, K. (2015). Bisphenol A (BPA) in food contact materials - new scientific opinion from EFSA regarding public health risk. *National Library of Medicine*, *66*(4), 299-307.

Vogel, S. (2009). The Politics of Plastic: The Making and Unmaking of Bisphenol-A "Safety". *National Library of Medicine*, *99*(3), 559-566. PubMed. 10.2105/AJPH.2008.159228

Mid-1930's

British medical researcher Edward Charles Dodds identified estrogenic properties of BPA

1976

US passes the Toxic Substances Act

-BPA declared safe and is not evaluated

1982

National Toxicology Program determines the lowest adverse effect level for BPA in lab animals is 50 milligrams of BPA per kg of bodyweight per day

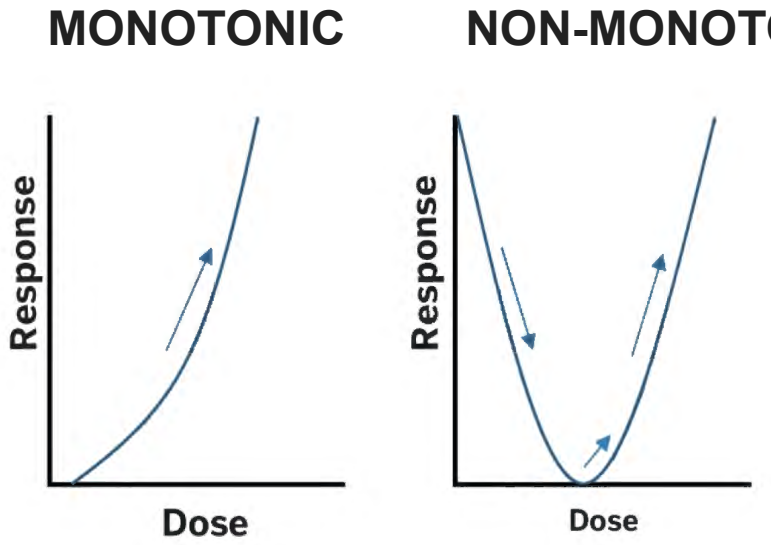
1988

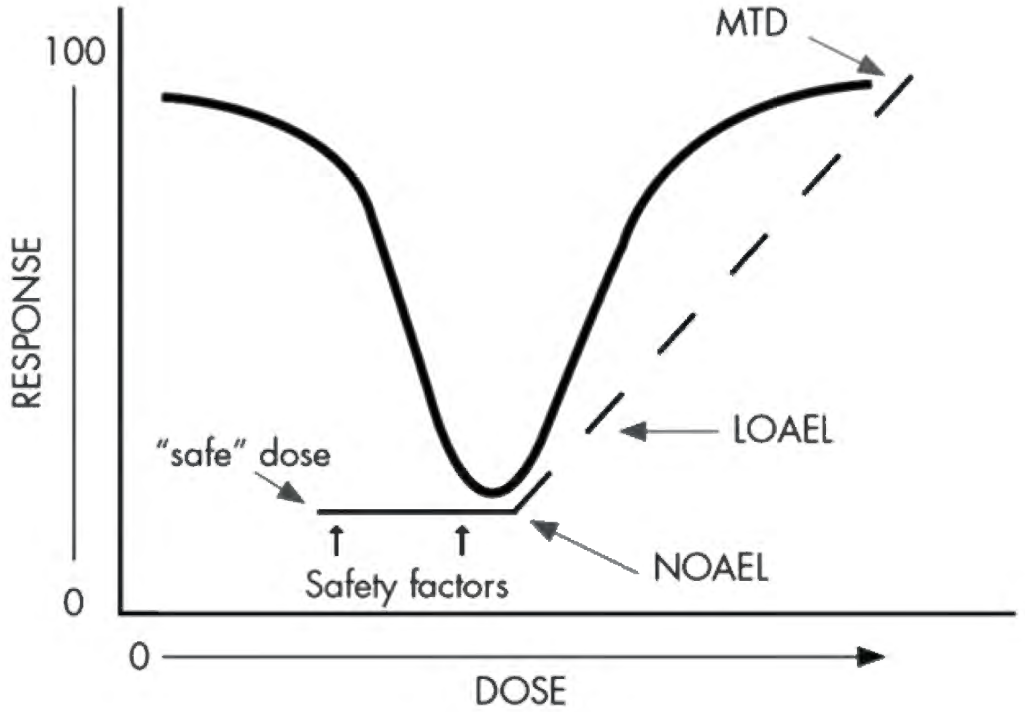
Tolerable daily intake (TDI) set at 50 µg/kg bodyweight (bw)

1993

Endocrinologists at Stanford University found that BPA was leaching from their polycarbonate flasks

Non-Monotonic Dose Response Curve (NMDRC)





Vandenburg, L. (2014). Non-Monotonic Dose Responses in Studies of Endocrine Disrupting Chemicals: Bisphenol A as a Case Study. *National Library of Medicine*, *12*(2), 259-276. PubMed.

Vandenburg, L. (2012). Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Dose Responses. *Endocrine Reviews*, *33*(3), 378-455. Oxford Academic. https://doi.org/10.1210/er.2011-1050

Erickson, B. (2014, May 19). *ENDOCRINE-DISRUPTORS*. C&EN. Retrieved April 21, 2023, from https://cen.acs.org/articles/92/i20/ENDOCRINE-DISRUPTORS.html

Low-Dose Testing

2000

EPA requested that the National Toxicology Program (NTP) review the research on effects of low dose exposure of estrogenic compounds, including BPA

2001

NTP concluded that there was credible evidence for effects from BPA exposure at or below the safety standard

Vogel, S. (2009). The Politics of Plastic: The Making and Unmaking of Bisphenol-A "Safety". *National Library of Medicine*, *99*(3), 559-566. PubMed. 10.2105/AJPH.2008.159228

HEALTH CONSEQUENCES OF BPA EXPOSURE

"Pronounced effects on the reproductive system, child development, metabolic disorders, obesity, endocrine disorders, and the nervous system; as well as being implicated in causing DNA damage & oxidative stress

Association between the BPA levels and tumor development including prostate, breast and lung cancer

auses Hormonal and Obesogenic Effects Comparable to
Review. *National Library of Medicine*, *12*(2), 532. PubMed.

Ma, Y. (2019). The adverse health effects of bisphenol A and related toxicity mechanisms. *ScienceDirect*, *176*, 108575. Elsevier. https://doi.org/10.1016/j.envres.2019.

Infant Exposure

1997

Studies revealed BPA leaching from formula cans and infant bottles

1999

FDA publicly asserts the safety of BPA exposure for bottle-fed infants

Biles, J. (1997). Determination of Bisphenol A Migrating from Epoxy Can Coatings to Infant Formula Liquid Concentrates. *Journal of Agricultural & Food Chemistry*, *45*(12), 4697-4700. American Chemical Society. https://doi.org/10.1021/jf970518v

Quitmeyer, A., & Roberts, R. (2007). Babies, Bottles, and Bisphenol A: The Story of a Scientist-Mother. *National Library of Medicine*, *5*(7), 200. PubMed. 10.1371/journal.pbio.0050200[7]

BISPHENOL-A (BPA) TIMELINE

1950'S

Industrial use in plastics

2003

National Institute of Health nominated BPA for evaluation by the Center for the Evaluation of Risk to Human Reproduction as a reproductive and developmental toxin

LATE 2006 TO EARLY 2008

US government-sponsored BPA assessments

-Chapel Hill expert panel at University of North Carolina

-Center for the Evaluation of Risk to Human Reproduction (CERHR) at the National Toxicology Program (NTP)

Vogel, Sarah A. "The Politics of Plastics: The Making and Unmaking of Bisphenol A 'Safety.'" *American Journal of Public Health*, U.S. National Library of Medicine, Nov. 2009, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2774166/.

Denoon, Daniel J. "FDA Bans BPA in Baby Bottles." *WebMD,* 17 July 2012, https://www.webmd.com/parenting/baby/news/20120717/FDA-BANS-BABY-BOTTLES.

BISPHENOL-A (BPA) TIMELINE

2012

FDA officially bans BPA in infant bottles

US launched the Consortiums Linking Academic and Regulatory Insight on Toxicity of BPA (CLARITY-BPA)

2015

Tolerable daily intake (TDI) lowered from 50 to

4 μg/kg bw/day

Ma, Y. (2019). The adverse health effects of bisphenol A and related toxicity mechanisms. *ScienceDirect*, *176*, 108575. Elsevier. https://doi.org/10.1016/j.envres.2019.

Jalal, N. (2018). Bisphenol A (BPA) the mighty and the mutagenic. *National Library of Medicine*, *5*, 76-84. PubMed. 10.1016/j.toxrep.2017.12.013

BISPHENOL-A (BPA) TIMELINE

2019

Results from the CLARITY-BPA studies were made publicly available
-statistically significant endpoints following exposure to 2.5 µg/kg bw/day of BPA

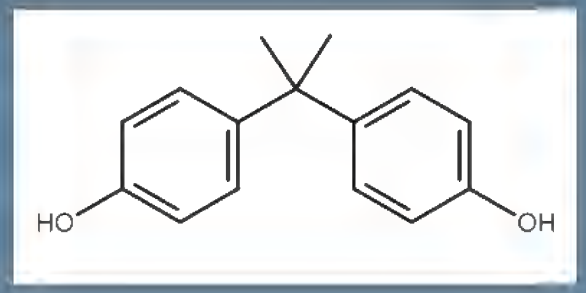
TODAY

Worldwide, BPA is one of the highest volume chemicals produced
5 million tons produced annually in US
5-6 billion tons produced annually worldwide

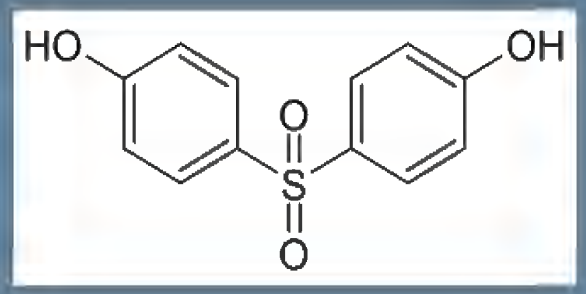
Rogers, L. (2021). What Does CLARITY-BPA Mean for Canadians? *National Library of Medicine*, *18*(13), 7001. PubMed. 10.3390/ijerph18137001

CDC Biomonitoring Summary - Bisphenol A. (2017). US Department of Human Health and Services. https://www.cdc.gov/biomonitoring/BisphenolA_BiomonitoringSummary.html

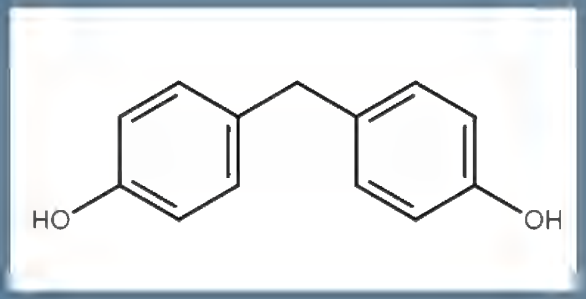
BPA ANALOGUES



BPA



BPS



BPF

A total of 16 BPA analogues have been documented for use in industrial applications

89.4% of American adults have BPS in urine, 66.5% BPF

A systematic review of 32 studies revealed BPF and BPS have a comparable potency to BPA and similar hormonal effects due to similar mechanisms of action

Thoene, M. (2020). Bisphenol S in Food Causes Hormonal and Obesogenic Effects Comparable to or Worse than Bisphenol A: A Literature Review. *National Library of Medicine*, *12*(2), 532. PubMed. 10.3390/nu12020532

Andujar, N. (2019). Bisphenol A Analogues in Food and Their Hormonal and Obesogenic Effects: A Review. *National Library of Medicine*, *11*(9), 2136. PubMed.

Women’s Health Concern

Estrogen mimic

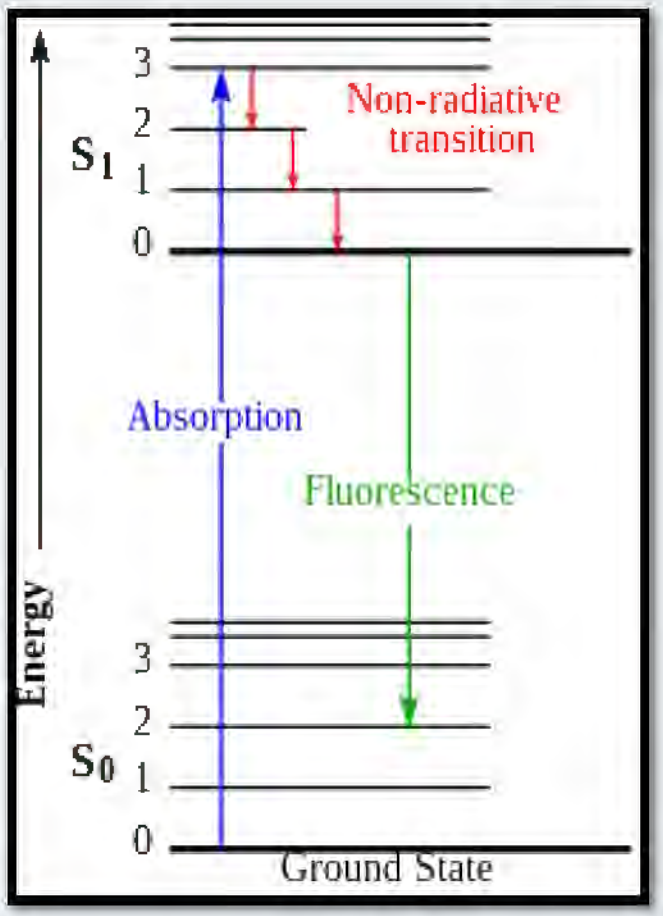
Confirmed BPA presence in feminine hygiene products reported in recent study by NYU Medical School

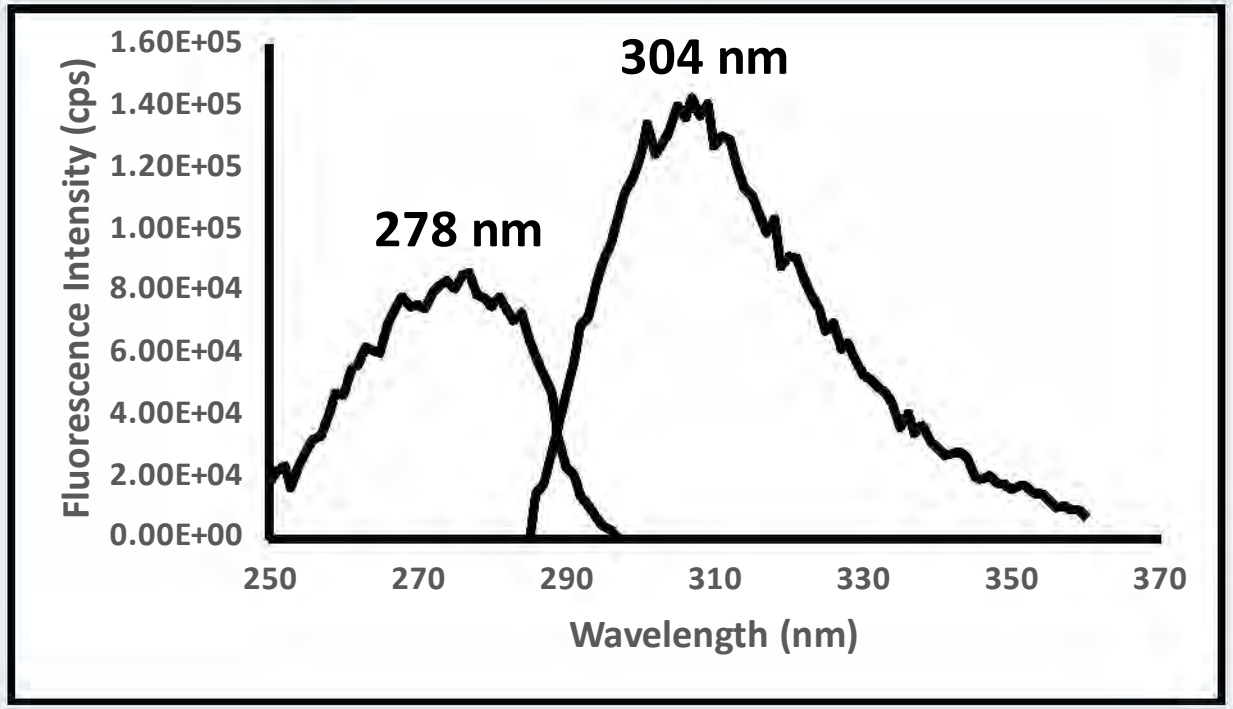
High absorption capacity of vulvar skin

Gao, Chong-Jin, Kannan, Kurunthachalam. Environ. Int.; 2020; Vol. 136;doi:10.1016/j.envint.2020.105465

Hill, Corinne E., et al. Developmental exposures to bisphenol S, a BPA replacement, alter estrogen-responsiveness of the female reproductive tract: A pilot study, 2017; Cogent Medicine, 4:1, doi:10.1080/2331205X.2017.1317690

Fluorescence Spectroscopy



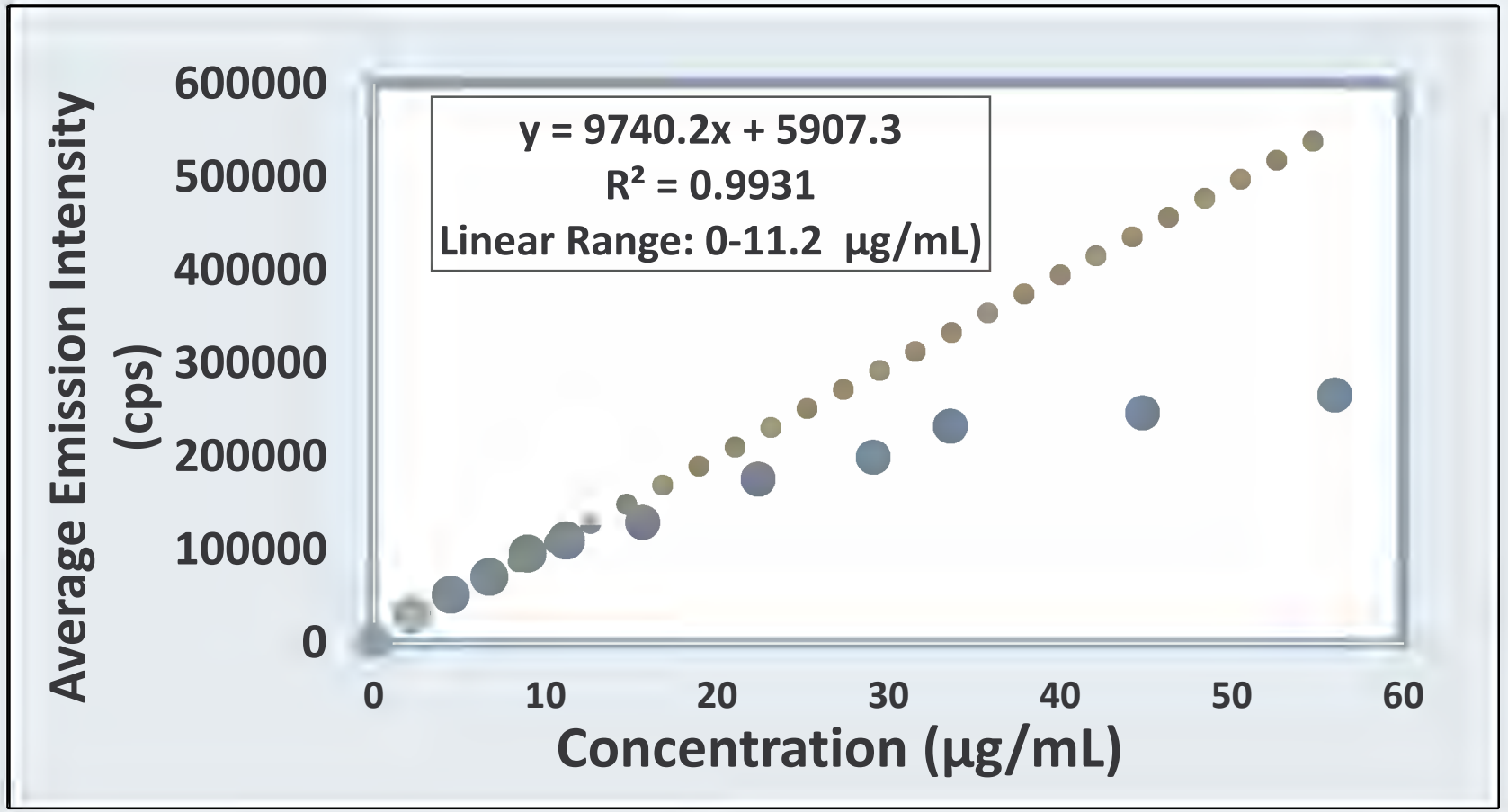


Excitation wavelength: 278 nm

Emission wavelength: 304 nm

"Jablonski Diagram." *Wikipedia*, Wikimedia Foundation, 13 Nov. 2022, https://en.wikipedia.org/wiki/Jablonski_diagram.

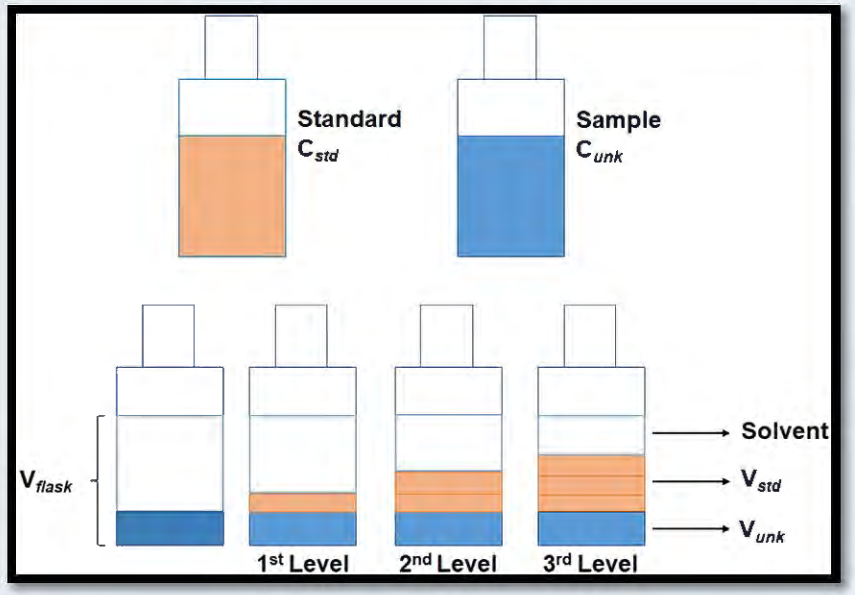
Calibration Curve

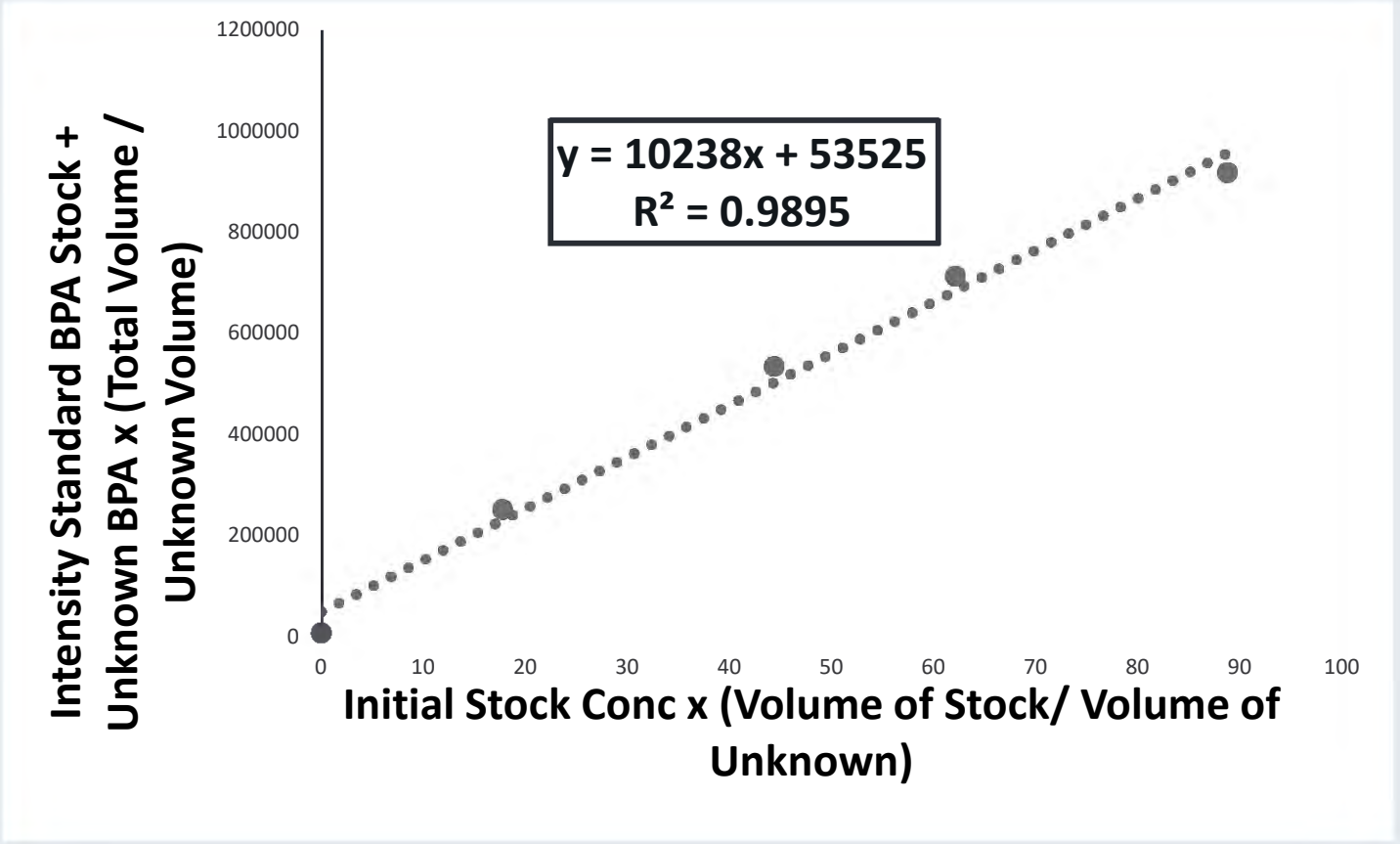


FS5 Edinburgh Instruments Spectrofluorometer

LOD = 0.06 µg/mL
LOQ = 0.21 µg/mL

Standard Addition Method

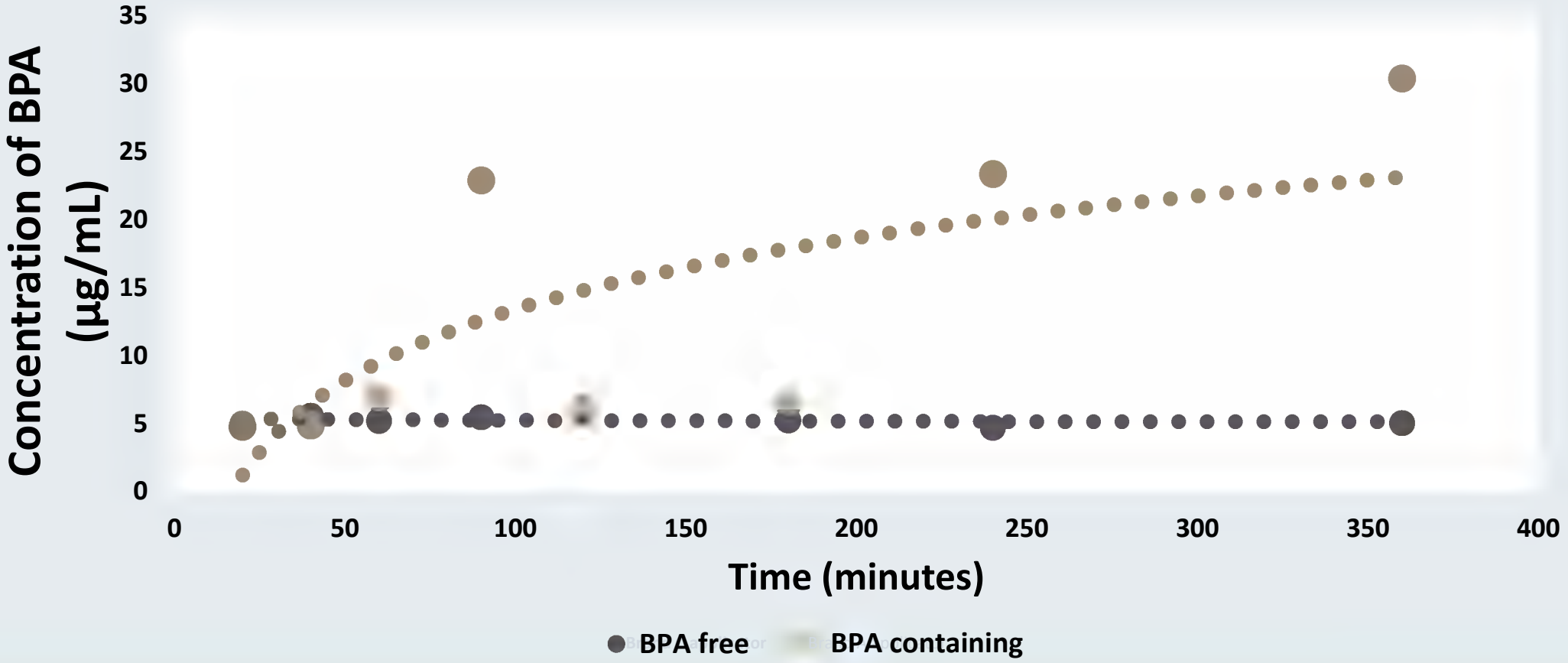




Representative Standard Addition Graph for Brand C applicators at 1 hour

Guerriero, Tatiane. "| Scheme of the Solution Preparation for the Standard Addition Method ..." *ResearchGate*, Apr. 2018, https://www.researchgate.net/figure/Scheme-of-the-solution-preparation-for-the-standard-addition-method_fig2_324249694.

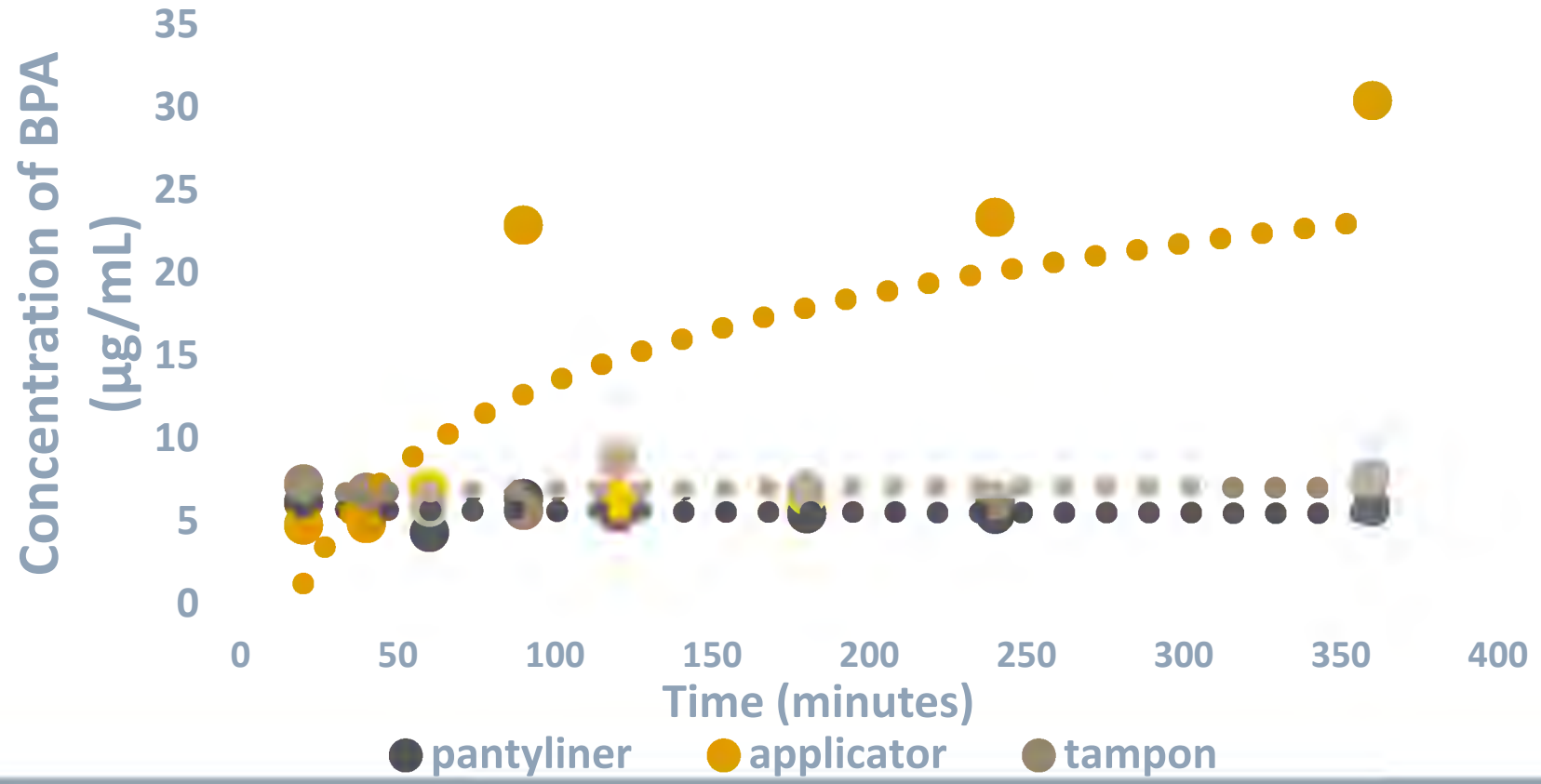
Standard Addition Method



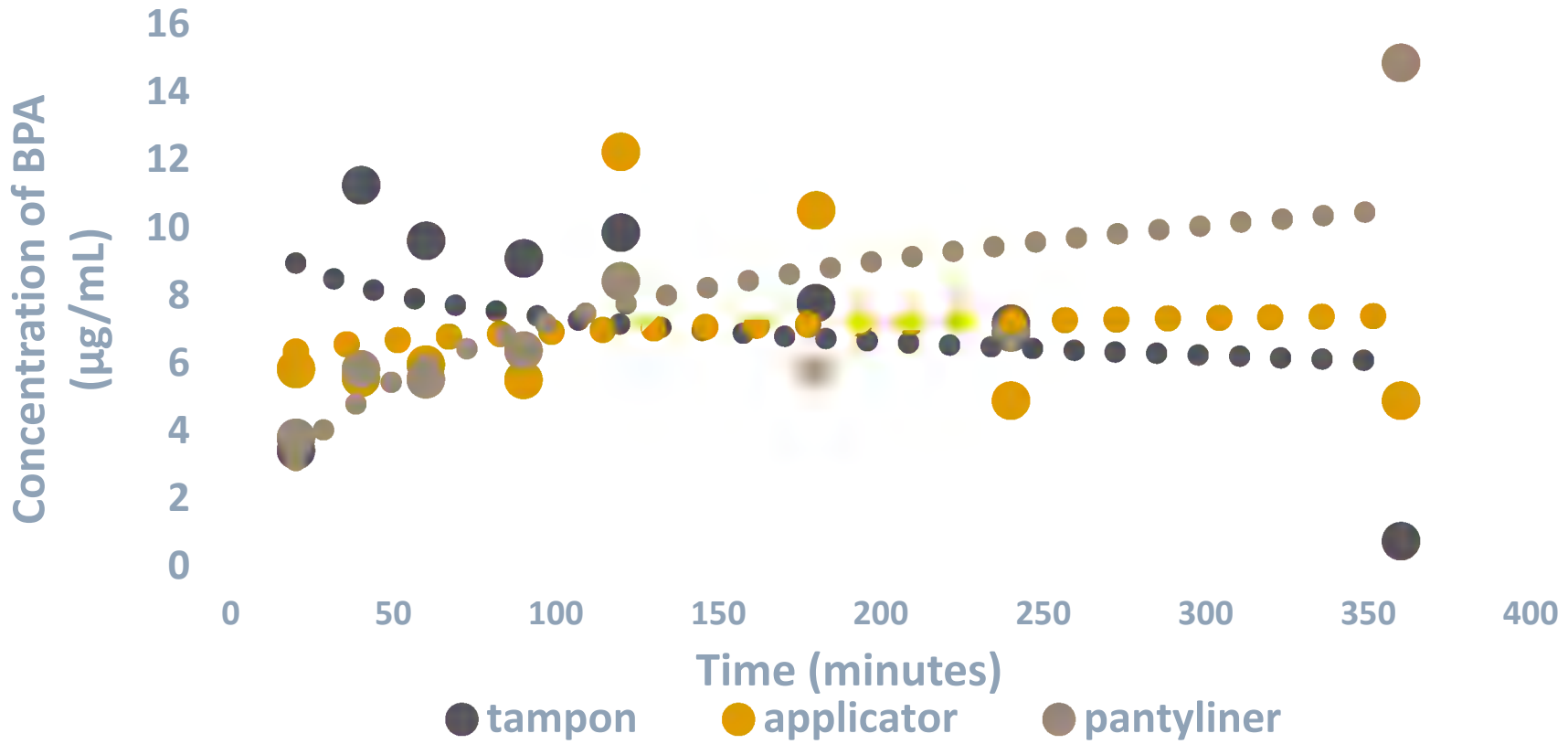
BRANDS TESTED

Brand	Brand A	Brand B	Brand C
Accessibility	Brand Name	Generic	Luxury
Price per Pantyliner	$0.08	$0.05	$0.19
Price per Tampon	$0.25	$0.14	$0.35

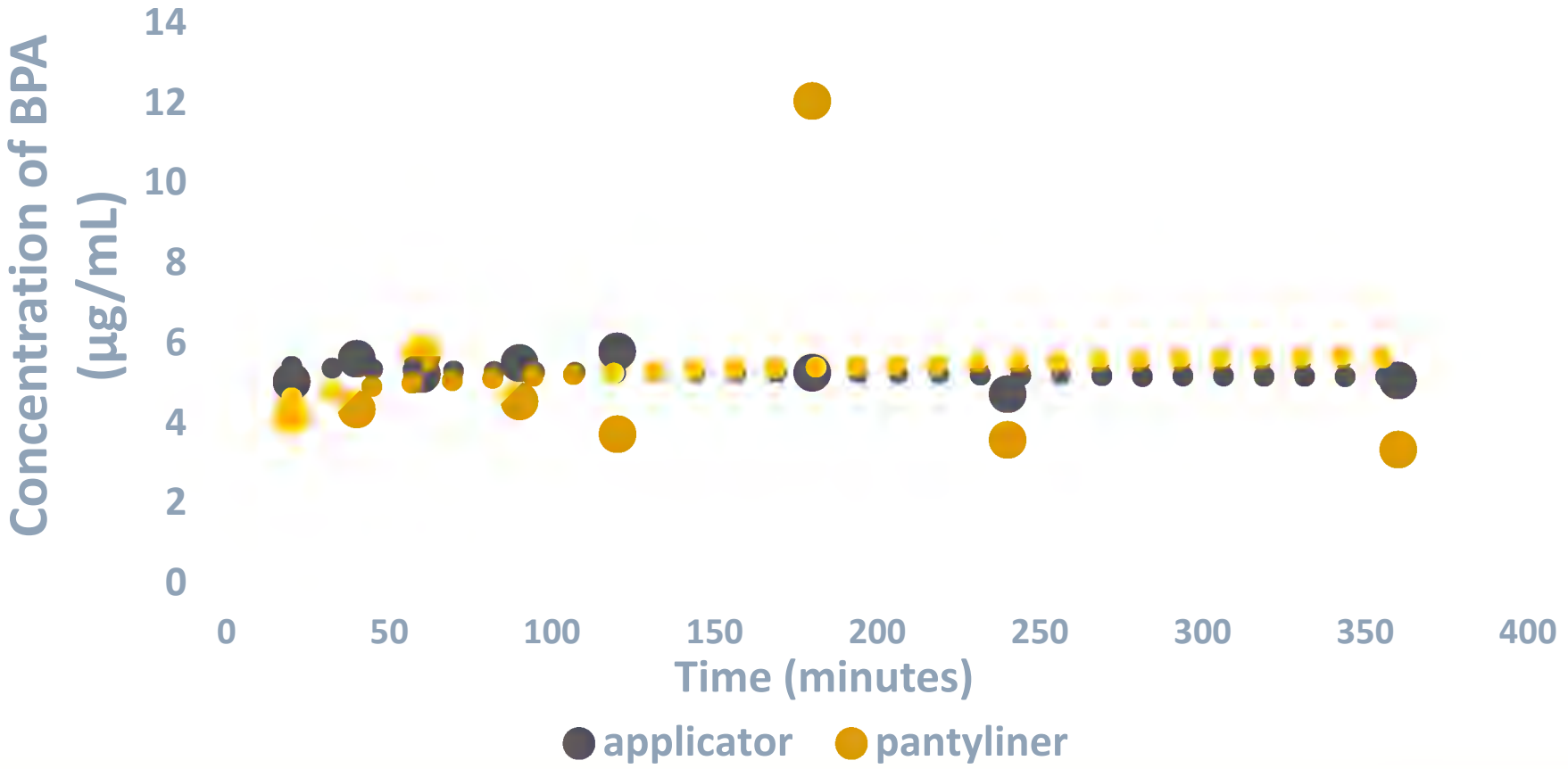
CONCENTRATION OF BPA LEACHING FROM BRAND NAME BRAND A PANTYLINER, APPLICATOR, AND TAMPON



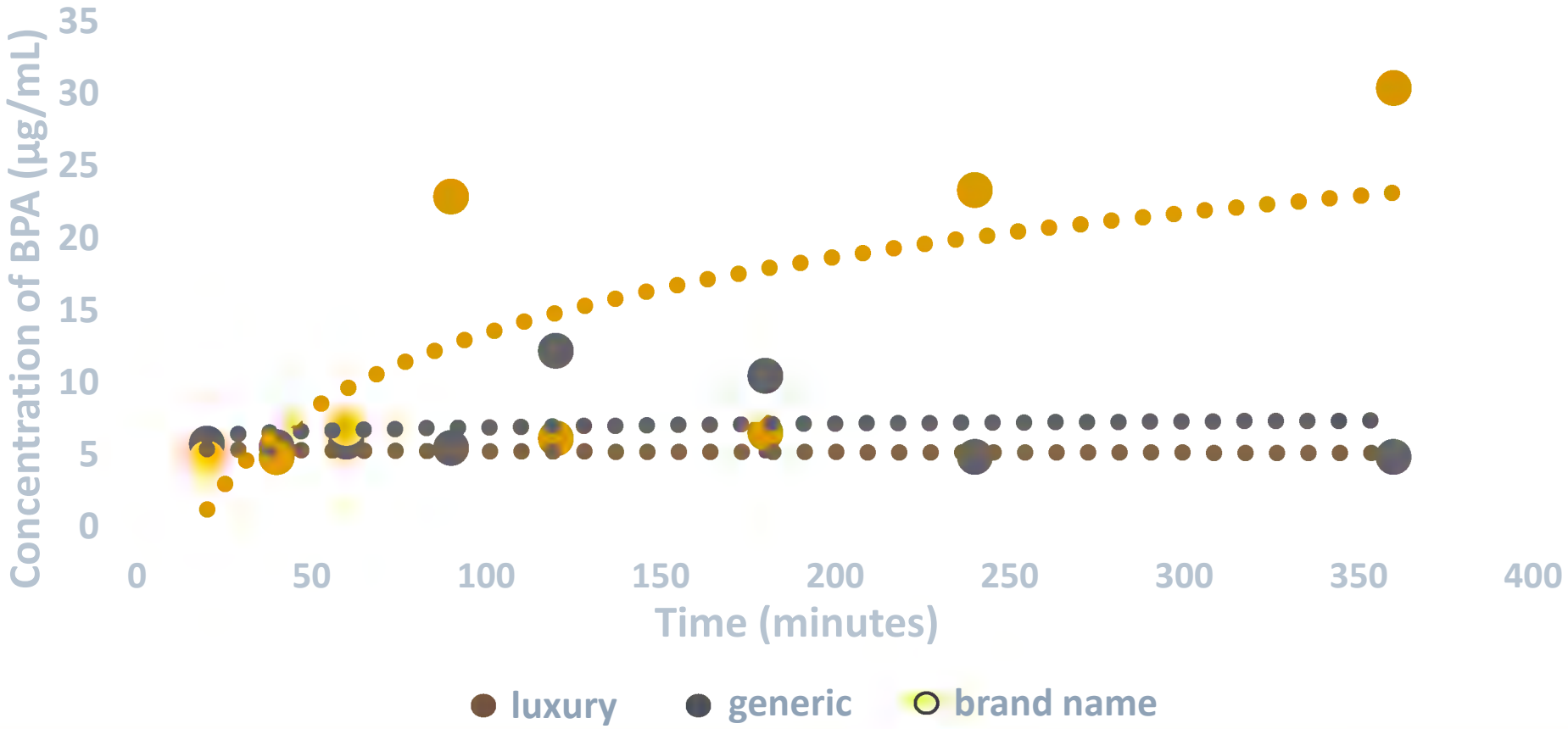
CONCENTRATION OF BPA LEACHING FROM GENERIC BRAND B PANTYLINER VS. APPLICATOR VS. TAMPON



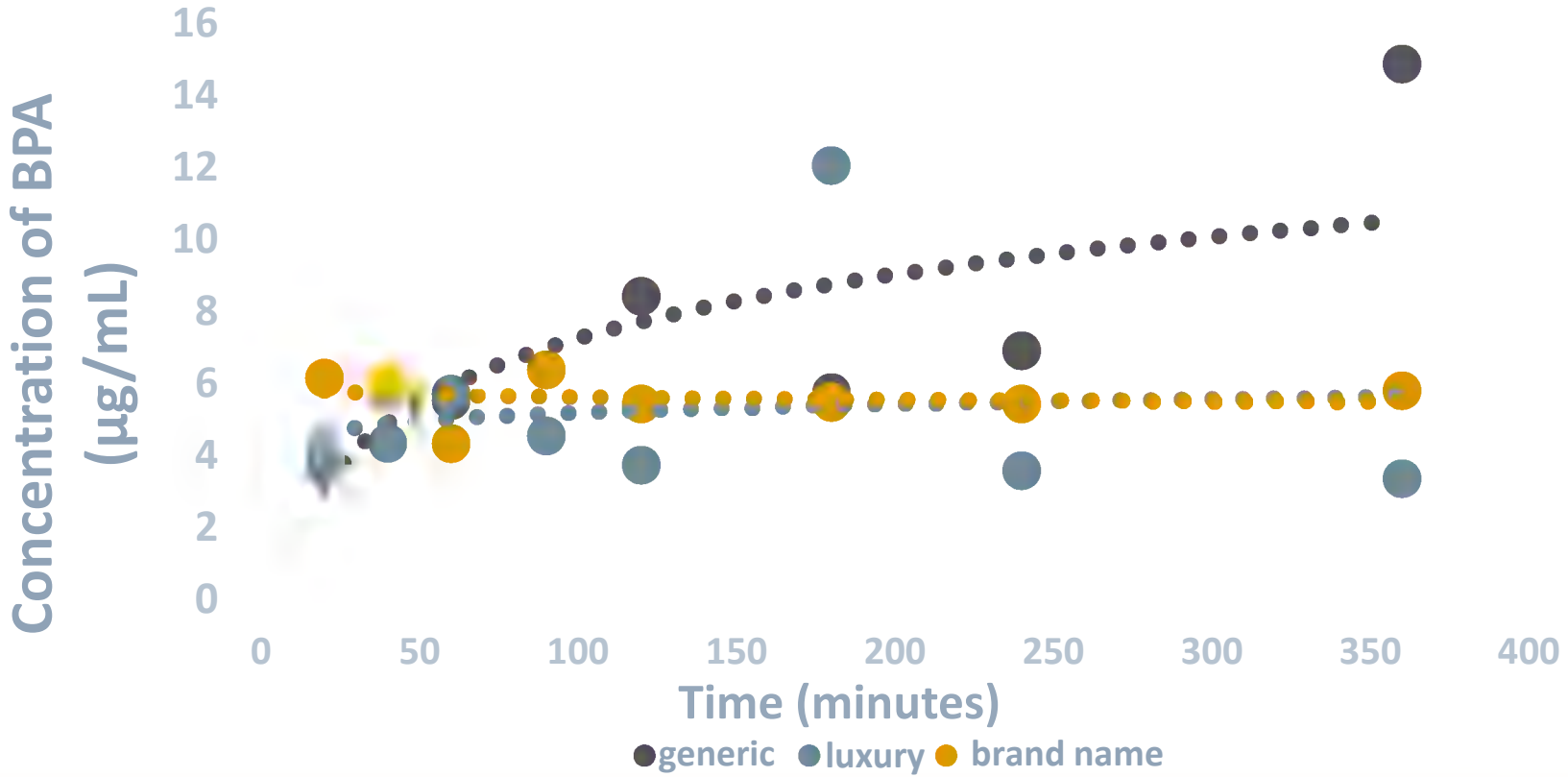
CONCENTRATION OF BPA LEACHING FROM LUXURY BRAND C TAMPON APPLICATOR VS. BRAND C PANTYLINER



CONCENTRATION OF BPA LEACHING FROM LUXURY BRAND C VS. BRAND B VS. BRAND A APPLICATORS



CONCENTRATION OF BPA LEACHING FROM BRAND A VS. BRAND B VS. BRAND C PANTYLINER



CONCLUSIONS

Both the pantyliners and tampon applicators of Brand C, a luxury brand which includes a BPA-free claim on its packaging, maintained a steady concentration of BPA in their solutions over 6 hours. This indicates that BPA concentrations in the brand's pantyliners and applicators were either very low or zero.

Brand A and Brand B showed a rise in the concentration of BPA leached out into solution from their tampon applicators over time. This indicates the presence of BPA in both brands' applicators.

Due to the steeper rise in each applicator's BPA concentration level compared to the tampon, the presence of BPA is higher in the tampon applicators compared to the absorbent component of the tampons.

CONCLUSIONS

Generic Brand B's pantyliner curve has a steeper increase in BPA concentration over time than its applicators and tampons. The tampon curve maintains the flattest progression, indicating it has the least BPA present and the pantyliner has the most BPA present.

Brand B pantyliners showed a steeper increase in the concentration of BPA leached into solution over time compares to both Brand A and Brand C pantyliners, indicating a higher level of BPA is in Brand B.

FUTURE WORK

Perform statistical analysis to validate these conclusions

Retest pantyliners and tampons in solution which more closely mimics vaginal pH during menstruation

Run samples for extended duration of time to analyze release of BPA from the product long-term