Fact Sheet on Bisphenol S (BPS)

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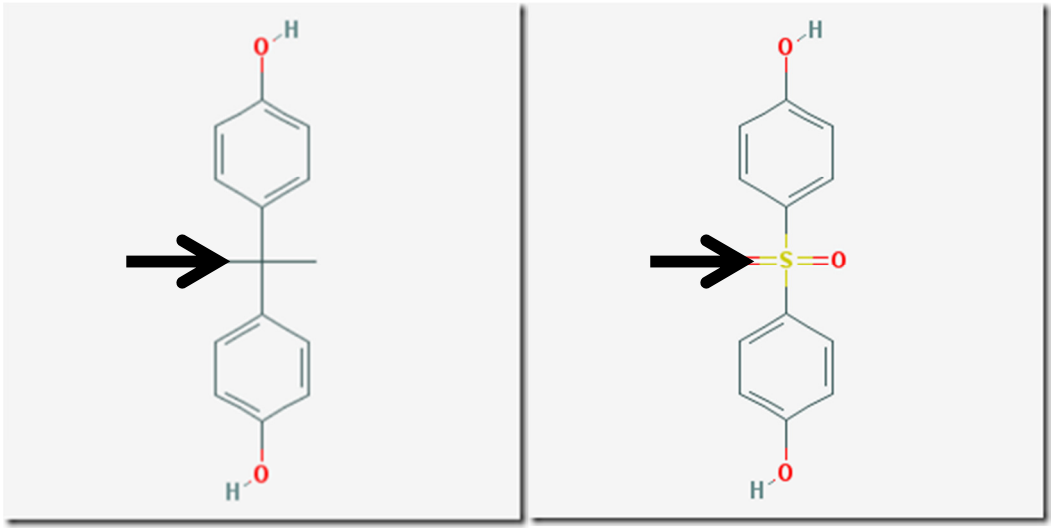
What is Bisphenol S?

- Bisphenol S (4,4'-dihidroxydiphenyl sulphone), abbreviated BPS, is an artificial, industrial, man-made chemical, belonging to a family of molecules known as bisphenols which consist of two hydroxyphenyl functionalities at opposite ends of the molecule.[1] There are at least 16 different bisphenols[2] but BPA and BPS are best known because they are endocrine disrupting compounds (EDCs), which may interfere with the normal activity of hormones such as estrogen, in the body thus leading to adverse health effects.[3]

How different are BPA and BPS chemically?

There is very little structural difference between BPA and BPS as shown below. [1]

BPA **BPS**



Arrow points to a carbon atom attached to two methyl groups.

Arrow points to a sulphur atom attached to oxygen atoms.

What is the relevance of BPS?

- The relevance of BPS is that it is increasingly being used as a replacement for BPA, especially as a colour developer in thermal receipt paper.[5,6,7,8]

What is the problem with BPA?

- There is growing evidence that BPA may be harmful to human health as outlined below: [9, 10, 11, 12, 13, 14]
- Increased risk of breast carcinoma [15]
- Increased risk of prostate carcinoma [16]
- Increased risk of obesity[17]
- Increased risk of diabetes mellitus type 2 [18]
- Increased risk of cardiovascular diseases [18]
- Increased risk of autoimmune diseases [19]
- Increased risk of asthma [20]
- Exposure associated with autism spectrum disorder (ASD) [21]
- Exposure associated with Attention deficit Hyperactivity disorders (ADHD) [21]
- Adverse effects of prenatal exposure for the brain [22]
- Adverse effects of prenatal exposure for behaviour [23]
- Adverse effects for prenatal exposure on immune function [24]
- Association with male sexual dysfunction [25]
- BPA may cause epigenetic effects [26]
- Environmental studies have shown that BPA has contaminated the planet except for the North Pole. [27]

The reaction against BPA

- In 1970 there were only two peer-reviewed publications on BPA while in 2011 there were 327. Overall, 3547 studies on BPA have now been published in Pubmed. This remarkable growth in BPA publications over 40 years shows that the effect of this chemical on the environment and human health is of great and growing concern.

- This concern has translated into the international banning of the importation, manufacture and selling of BPA-containing polycarbonate baby bottles in all the major countries of the world, including South Africa.[28, 29,]

- While the polycarbonate baby bottle was only a minor source of BPA, it was the first to be banned because of concern for babies who lack BPA-metabolising enzymes during the first years of life and who are more susceptible for epigenetic changes during early postnatal exposure to BPA. Over and above this concern about long term health of the babies exposed to BPA was the growing importance of the Precautionary Principle [30] which encapsulates the concept of being “rather safe than sorry”, i.e. that exposure to a potentially dangerous factor, such as BPA, should be terminated, before all the facts are known, if there is a reasonable case to be made for harm.

- On the 11th April 2013, France’s Ministry for Ecology, Sustainable Development and Energy requested the country’s Agency for food, health and occupational health and safety (Anses) to prepare a proposal to restrict the use of BPA in thermal receipt paper at EU level.[31,32].

- Consumers worldwide have become aware of the reported dangers of BPA and do not wish to become contaminated with this chemical in any way, including the handling of thermal invoice paper. [33,34, 35]

- BPS has been suggested as a substitute for BPA. For example, Japan phased out BPA in thermal receipt papers in 2001[36], and a major manufacturer of thermal receipt papers in the USA reported replacement of BPA with BPS[3,5,.37] Consequently businesses worldwide have sought alternatives for BPA and have chosen thermal paper containing BPS and no BPA. Some of these businesses claim that they are now “BPA-free” and that the problem has been solved.However, bisphenol S has been shown to have similar estrogenic activity to bisphenol A and so its main advantage in these applications is merely that it escapes the legal prohibition on bisphenol A and allows products containing bisphenol S to be labelled "BPA free"[38].

Characteristics of BPS:

- BPS is an endocrine disruptor molecule as is the case with BPA.[39,40,41,42]

- When added to GH3/B6/F10 rat pituitary cells in tissue culture BPS phosphoactivated the ERK extracellular signal-regulated kinase within 2.5 min.[41]

- This hormone (estrogen)-like effect was detected at extremely low concentrations of BPS (10^{-15} M). (To get an idea how low this is, in order to make a 10^{-15} M solution of BPS you would dissolve 1 ug (one millionth of a gram) of BPS in an Olympic swimming pool with a volume of 2.5 million liters).[41]

- BPS induced cell proliferation similar to estrogen.[41]

- The authors of this work concluded ***–"BPS, once considered a safe substitute for BPA, disrupts membrane–initiated E2-induced cell signalling, leading to altered cell proliferation, cell death, and prolactin release.***" [41]

- BPS was detected in 97% of urine samples from residents of Albany, NY, in substantial amounts (0.299 ng/ml).[42]

- BPS has increased stability against high temperatures and increased resistance to sunlight compared to BPA [37].

- BPS does not break down readily in seawater as is the case with BPA. This raises the concern that BPS could accumulate in the environment.[43]

- Paper coated with BPS may contain up to 40% more chemical than is the case with BPA because BPS is a weaker developer than BPA.[44]

- In Albany, NY, the median amount of BPS in a gram of thermal invoice paper was 7.44 mg/g. [43]

- BPS in different thermal invoices ranged from 0.0000138 to 22.0 mg/g (GM: 0.181 mg/g;). This indicates a lack of control on the amount of BPS allowed in a gram of thermal paper.[43]

- The estimated daily intake of BPS from thermal invoices by average consumers is a median of 291 ug/day.[43]

- The estimated daily intake of BPS from thermal invoices by those with occupational exposure is 21804 ug/day, i.e. **75-times more than average consumer.**[43]

Conclusions

- BPS, like BPA behaves like an endocrine disruptor compound (EDC) at very low concentrations and competes with estrogen.

- Although BPS has not been studied as well as BPA it is a reasonable assumption based on the almost identical chemical structures that BPS will show many of the adverse health effects found with BPA.

- More BPS than BPA is needed in thermal receipt paper for adequate colour development and it can be expected that BPS contamination of humans will be similar if not more than with BPA-containing receipt papers.

- Occupational handlers of thermal receipt paper can have a much higher exposure to BPS and deserve special attention from management to reduce exposure.

- BPS is more heat and light stable than BPA and is not found to break down in sea water. This suggests a high pollution potential for BPS as it is used more and more.

The way forward

- It is clear from this brief analysis that BPS is not the answer to the BPA problem.

- Thermal till slips are a major advance but the use of BPS and BPA as colour developers in the slips are stumbling blocks because they are endocrine disruptor molecules which have been linked to many adverse health effects including prostate and breast. cancer.

- What is needed is a real BPA alternative which is not a hormone disruptor and which is not readily absorbed into the human body[45].

- This will be no easy task because 19 chemical alternatives have been tested and no clear winner was found.[46]

- Until such a solution is found it is necessary to handle thermal invoice paper with care and to wash hands after doing so.

- Prof Frederick vom Saal, University of Missouri-Columbia's Endocrine Disruptors Group is quoted as saying ***- "The immediate consequence of touching thermal paper coated with free BPA or BPS is that you will spread the chemical onto everything you touch until you wash your hands"*** [39]

- Thermal invoices should not be kept too long in purses and wallets because the BPS contaminates currency notes.[44]

- Those handling thermal invoices occupationally such as till-operators need to clean their hands on site often and be particularly careful when pregnant because hormone disrupters are thought to be particularly active on the unborn foetus.[47]

- Safety aspects of BPS need to be investigated comprehensively especially in terms of adverse health effects after chronic exposure. [48]

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