Newspaper or Other Recycled Paper

Crops

Identification of Petitioned Substance

Chemical Names:
Cellulose (the primary constituent)

Other Names:
Paper, recycled paper, newspaper, newsprint, shredded newspaper, papyrus, tissue, bond, cardboard, boxboard, (paper) bags, Kraft paper, linerboard, backliner, tarpaper, papel reciclado (Sp.), papier recyclé (Fr.).

Trade Names:
DeWitt Biodegradable Weed Barrier; Easy Gardener Natural WeedBlock Biodegradable Mulch; Planters Paper Mulch; WeedGuard Plus Biodegradable Paper Weed Barrier

CAS Numbers:
9004-34-6 (Cellulose, the primary constituent)

Other Codes:
none

Summary of Petitioned Use

Newspaper or other recycled paper without glossy or colored inks is currently allowed under the National Organic Program (NOP) regulations at 7 CFR 205.601(b) as mulch and 205.601(c) as a compost feedstock.

Characterization of Petitioned Substance

__Composition of the Substance:__
The composition of paper varies according to the origin of the fibers, the manufacturing process by which it is made, and the additives used to modify its functionality. Cellulose and starch may make up more than 95% by weight of finished paper (Hagiopol and Johnston 2012). Newsprint will have a lower cellulose content and higher lignin than office paper. Kraft process paper will have higher cellulose content than sulfite process paper. Pure cellulose is a network of carbohydrate molecules, $(C_6H_{10}O_5)n$, shown in Figure 1, which are then glued together by a simple sugar, glucose (Merck 2015). Starch is an amorphous polycarbohydrate that serves as the glue that binds the cellulose fibers, and also serves as the carrier for inks and other chemicals used to treat the paper. Other constituents include hemicellulose and lignin, as well as a small amount of extractive resins from wood (Hubbe 2005). Hemicellulose and lignin are more complex and random amorphous structures than starch and cellulose with monomers of greater molecular weight.

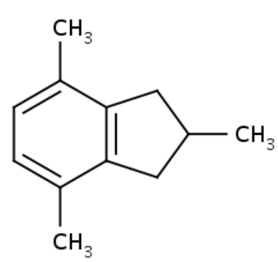

Figure 1: Cellulose Monomer (US EPA 2015a)

Traditional paper processing has used gelatin as an additive since the 14th century CE, and "papermakers' alum," or aluminum sulfate, since the 17th century CE. Various fillers have been used nearly as long. Modern paper products also use a wide variety of synthetic polymers and co-polymers that change the functionality and performance of the paper compared with simple cellulose-starch blends (Auhorn 2012; Hagiopol and Johnston 2012). Aluminum foil and paraffin waxes are added to paper and paperboard used in food packaging. These composite papers are discussed in greater detail below.

Newspaper and other printed matter have inks, dyes and toner (a solid powder used for electrostatic or electrophoretic printing). Most ink in newsprint and office paper is black, but colored inks and dyes are used on various printed material and packaging. With the advent of color printing processes, more newspapers and office paper applications involve colored ink. More printing is done with colored toner as well.

Some papers do not use inks or toner for printing. Thermal paper changes color when heat is applied. The prevalent reactant acid used in thermal paper is bisphenol A (BPA) (Liao and Kannan 2011). BPA is also used in flyers, magazines, newspapers, napkins, paper towels, toilet paper and paper cups.

Source or Origin of the Substance:

Paper is made from various plant materials, including wood, trees, straw, hemp, sugarcane bagasse, bamboo, reeds and kenaf. Most paper continues to be produced from wood fibers (Hubbe 2005). At this point, most trees grown for paper production are not genetically modified. However, genetically modified trees have been developed and may be used for paper production. The traits for which trees are being genetically modified include reduced lignin, higher cellulose content, fiber structure that is more easily pulped by enzymatic action (Pilate et al. 2002; Baucher et al. 2003), insect and disease resistance (Hu et al. 2001; Mentag et al. 2003; Merkle et al. 2007), and rapid growth, among other traits (Harfouche, Meilan, and Altman 2011). China began commercial plantings of genetically modified trees in 2002 (FAO 2004). The U.S. has permitted plantings of genetically modified papaya and one plum variety, but not commonly pulped species (Häggman et al. 2013). Commercialization of genetically modified forest trees has faced challenges in the U.S. and elsewhere for reasons such as inadequate financial returns on investment, government regulation that limit plantings, and lack of public acceptance (Sedjo 2006).

Paper can also be recycled. Recycled content varies by country of origin. In general, there has been an upward trend in the percentage of paper made from recycled sources. Paper produced in the United States is estimated to be between one-third to almost one-half recycled content (Roberts 2007). The United States recovers and recycles a lower percentage of paper than other countries. In 2002, the United States used about 41% recycled paper in its manufacturing. While paper recycling has increased fivefold in the United States since 1990, according to the U.S. Environmental Protection Agency (EPA) the growth in recovery has flattened out (U.S. EPA 2015). Since 2001, paper de-inking capacity has declined slightly (Roberts 2007). About 63% of all paper generated is recovered, but in 2013 it still accounted for about 27% of what was sent to landfills in the United States. This makes paper and paperboard the largest single category of municipal solid waste (MSW) by almost twice as much as the second largest category, food waste (U.S. EPA 2015). The third largest category, yard trimmings, is also compostable.

Recovered paper can come from a number of different sources, and may be made into a variety of products based on the grade. The U.S. EPA recognizes five basic paper grade categories: old corrugated containers , mixed paper, old newspapers , high grade de-inked paper, and pulp substitutes (U.S. EPA 2016a). These five major categories are further segmented by sources, uses, and levels of contaminants. The Institute of Scrap Recycling Industries (ISRI) recognizes over 50 grades of scrap paper (ISRI 2013).

Old corrugated cardboard traditionally has the highest recovered paper utilization rate (Blechschmidt et al. 2012). Newspaper—which includes magazines and other printed matter—is usually in second place. The highest grade is high grade de-inked paper, which is suitable for making letterhead and copier paper. The lowest grade of paper is mixed paper. The EPA does not recognize shredded paper as a grade, but acknowledges that it can be recycled "as long as it is shredded to an appropriate size and does not contain an unacceptable level of contaminants, such as plastics" (U.S. EPA 2016a). Paper and paper manufacturing by-products that are unsuitable for recycling are more likely to be used as compost feedstock and mulch than higher grade recovered paper that can be used to make paper. In general, it is the lowest grade of paper that is relegated to mulch and compost feedstocks, since they are the lowest value products made from recovered paper.

At the broadest level, paper can be recovered from within the manufacturing process from material not suitable for sale or consumer use. Such material has long been commonly recycled by industry, and is not seen as reducing demand for landfill. Material that has been sold, used, discarded and collected is considered 'post-consumer' waste. Paper can be source separated at collection, mixed with other recycling and separated after collection, or separated at a materials recovery facility (MRF) with unseparated garbage. One study in the U.K. found that pre-sorted paper for recycling had over 99% content that could be pulped, while paper recovered from commingled collection had an average of about 12% usable content (Miranda et al. 2013). In another survey in the United States, only about 25% of paper mills surveyed purchased scrap paper recovered from MRFs (ISRI 2016). Most purchasers of scrap paper surveyed (70%) reported that scrap paper from an MRF was worse than other sources of recovered paper, with 90% saying that they rejected or downgraded MRF sourced scrap paper they had purchased.

Paper considered unsuitable for recovery, repulping or recycling into paper, or otherwise rejected by pulping mills, can still be used to make compost and may be used as a feedstock in MSW compost (Gupta and Garg 2009; Nguyen 2012; Smith et al. 2015). Reasons for rejection include the presence of food-soiled paper or napkins, and amounts too small to bale for transportation to the de-inking facility. However, some paper is also rejected due to toxic contaminants and other impurities. Plastics, motor oil, paint, glass, and other non-paper materials may interfere with the composting process, downgrade compost quality, or even render the compost harmful to soil organisms, plants and humans. The less pre-sorting done with recovered paper, the greater the perceived likelihood that it will have contaminants that interfere with recycling and composting (ISRI 2016).

Inks and Toners

Printing has been mostly a wet-chemical process done with liquid inks. Since the 1950s, with the invention by Xerox of dry chemical printing, more paper is produced using dry toner. Black inks are composed primarily of oils, which may be of petroleum or vegetable origins, and carbon black, which is mostly produced from petroleum. Most modern newspaper inks or 'news blacks' are produced from naphthenic petroleum oils (US Ink 2000). The next most prevalent ingredient is carbon black, which is also primarily a petroleum derivative. Carbon black may also be produced from coal tar (Iyengar et al. 1971) and may use rubber from recycled tires and recovered plastics (Zhou and Xing 1998). A number of solvents are used in commercial inks, including toluene, xylene, methyl chloroform, methyl isobutyl ketone, and hexane (Miller 2008). Because of environmental considerations, these solvents are being replaced with water-based inks. While these inks have reduced solvents to less than 1% of the formulation, they are not solvent-free (Frank and Rupp 2012). Prior to the development of fossil fuels, ancient black inks about 4,500 years ago were made from animal or vegetable charcoal mixed with glue (Ritter 1998). Charred animal and vegetable material may make up a small fraction of current production of carbon black, but this is exceptional and not the industry norm.

Colored ink has a different composition from black ink, and it is more highly variable. As previous technical reviews noted, formulations vary widely (Cotner, Sideman, and Heckman 1995; ICF Consulting 2006). Ancient sources of dyes for colored ink were from plants such as indigo, and animals such as squid. Pigments are suspended solid particles that are delivered with the ink. Dyes are dissolved in the ink and as such permeate the paper, making it more colorfast, which means they are less likely to fade and also more difficult to remove.

Various elemental 'heavy metal' compounds are used as pigments in certain colored inks (Ritter 1998; Eastaugh et al. 2004). The compound of greatest toxicological concern has been lead chromate ($PbCrO_4$) or 'chrome yellow' (U.S. NLM 2016). Another ink ingredient of toxicological concern is cadmium sulfide (CdS), also known as 'cadmium yellow' (Eastaugh et al. 2004). Mercury is also used for a variety of pigments in inks, in particular mercuric sulfide (HgS) used for red pigmentation. Other elemental based pigments include cobalt blue ($CoAl_2O_4$), chrome green (Cr_2O_3), molybdate orange ($Pb(CrMoS)O_4$), Paris green ($Cu(C_2H_3O_2)_2 \cdot 3Cu(AsO_2)_2$), and Prussian blue ($Fe_4[Fe(CN)_6]_3$ (Ritter 1998; Eastaugh et al. 2004). With the development of ink jet technology, office and home applications of colored printing have become more widespread. Ink jet printers use liquid ink with proprietary solvents and dyes in a four-color electrostatic process (Bassemir and Bean 2004).

The use of heavy metal based pigments has been reduced due to environmental and health concerns, but they remain in use for certain print applications (Miller 2008). On the other hand, the use of colored ink in newspaper printing has increased (Tucker et al. 2000). Many colored inks are proprietary formulations and some specific compositions are highly guarded trade secrets (Bassemir and Bean 2004). Because of the proprietary nature of ink formulations, it is not possible to say how widely each formulation is used, although as hazardous substances they would presumably be reported on the individual ink's Safety Data Sheets (SDSs).

Electrostatic printing was patented by Chester Carlson in 1942 (Carlson 1942). His company, Xerox, went on to manufacture and market photocopiers and printers based on the process. The original toner described in the patent was composed mostly of sulfur, anthracene and anthraquinone, the latter two being coal derivatives. Newer black toners use polymers and iron oxide (Hasegawa et al. 1991). Color electrophoretic printing was developed in the 1960s (Oster 1964; Tulagin and Carreira 1968). These patents disclosed over 100 different dyes and pigments that could be used. The formulations of the pigments were not fully disclosed in the patents. Many were azo- or anthraquinone-based, and a number included different metallic agents, including cadmium, chromium and copper.

Gloss

Glossy paper as well as higher grade stationary may use fillers—such as clay or titanium dioxide—in the papermaking process. These mineral fillers increase the weight, brighten the finish, help the gloss adhere to the paper, and create a smoother finish. The clays may be from nonsynthetic sources, such as bentonite or kaolinite. Various petrochemical polymers, such as acrylonitrile, polyethylene (LDPE), styrene, butadiene, vinyl acetate, and polyvinyl chloride may also be used to create a glossy finish (Wesslau et al. 1968; Nadeau et al. 1970; Whitfield Associates 2008). Various resins are used to laminate the gloss and bind the polymer to the paper surface.

Adhesives and Glues

Many paper products have adhesives (Onusseit et al. 2000). Glues are the oldest adhesives, derived from mucilaginous parts of rendered animals. Starches derived from plants also have a history of use as adhesives. Modern adhesives are mostly petroleum derivatives. Corrugated cardboard uses various adhesives to attach the smooth and corrugated layers. These may include formaldehyde, urea, melamine, and starch based resins (Fischer and McElmury 1969). Various glues and adhesives are also used in envelopes, packaging, paper bags, and a wide variety of consumer, office and industrial paper products.

Most of the adhesives were found to be proprietary. They may be pressure sensitive, applied at ambient temperatures by pressure; cold set, where the adhesive dissolves at an elevated temperature and gelatinizes while cooling; or hot melt, where solids are heated to liquid phase and applied where they solidify as they cool. One non-proprietary cold-set adhesive is polyvinyl alcohol (Sumi et al. 1984). Hot melt adhesives are used for case sealing, carpet backing, and bookbinding. Historically, the main hot melt adhesive was ethylene vinyl acetate (EVA) (Midwest Research Institute and Franklin Associates 1975). Polyolefin and polyamide based adhesives are replacing EVA for many hot melt applications (Onusseit et al. 2000). Gamma radiation may also be used to cure adhesives as well as sterilize packaging. This is more common for medical and pharmaceutical applications than for food packaging (Onusseit et al. 2000).

Waxes, Resins and Polymers (Plastics)

Paper and cardboard products that are exposed to moisture will often be waxed or coated with a water-repellent resin to prevent absorption and increase wet strength. The waxes used are mostly paraffinic. One common application is for coating boxes used to pack fresh produce that is subject to hydrocooling. Resins may be derived from pine tar or other plant sources. Tarpaper is not as common as it once was, but it is still used for some construction and other outdoor applications. The tar used in tarpaper may come from pine tar, coal tar, or asphalt from heavy crude petroleum. Reclaimed tarpaper is especially challenging in terms of recycling procedures (Midwest Research Institute and Franklin Associates 1975).

As mentioned above, a growing number of paper products are manufactured as composites of cellulose and synthetic polymers or 'plastics' (Auhorn 2012; Hagiopol and Johnston 2012). These include polyethylene, polyacrylimides and polyesters. Some applications are used to provide ionic charges—both anionic and cationic—to paper, while other applications use anionic polymers.

Properties of the Substance:

The properties of paper vary widely based on sources, manufacturing processes, uses and applications. Specifications are set by the private sector or by government procurement agencies. Paper surface chemistry will vary based on whether the paper will be used for printing, and if so by what method. Paper may be treated to absorb or repel moisture. Private industry standards for paper quality in the United States are established by the Trade Association of the Pulp and Paper Industry (TAPPI). International standards are set by the International Organization for Standardization (ISO).

The chemical and physical properties of various types of paper are summarized in Table 1.

Table 1: Chemical and Physical Properties of Various Paper Products

Property	Value	Source
Grammage (Basis Weight)	Newsprint: 40-50 g/m^2 Bond: 30-90 g/m^2 Paperboard: 120-300 g/m^2	(PaperOnWeb 2016)
Color	White (Bleached) Brown (Unbleached) Multi-colored (Printed)	(Hubbe 2005)
Thickness	Newsprint: 85 µm Bond: 100 µm Linerboard: 230 – 640 µm	(Hubbe 2005)
Cellulose content	Newsprint: 73% Bond: 75% Magazine (Glossy): 57% Cardboard: 82%	(Sundqvist 1999)
Lignin content	Newsprint: 26% Bond:<1% Magazine (Glossy): 10% Cardboard: 10%	(Sundqvist 1999)
Mineral content (Ash)	Newsprint: 0-12% Fine paper: 0-35% LWC (Glossy): 30-50%	(PaperOnWeb 2016)
Cadmium (Cd)	Newspaper: 0.44 ppm Other paper: 0.90 ppm	(Tucker et al. 2000)
Chromium (Cr)	Newspaper: 5.53 ppm Other paper: 18.60 ppm	(Tucker et al. 2000)
Lead (Pb)	Newspaper: 10.55 ppm Other paper: 30.20 ppm	(Tucker et al. 2000)
Mercury (Hg)	Newspaper: 0.06 ppm Other paper: 0.16 ppm	(Tucker et al. 2000)
Ink oil content	Newsprint: 3,000 mg/kg Cardboard: 300-1,000 mg/kg	(Biedermann and Grob 2010)

During the wet phase of manufacturing, paper chemicals added to the pulp make up less than 5% of the weight of the cellulose in most cases. These may be added as liquids, as soluble solids, or solids in suspension. In many cases, these are removed as effluent in either the liquor or sludge. For finished paper, non-paper chemicals generally make up less than one percent of the total weight of paper (Hagiopol and Johnston 2012).

The composition of ink varies widely and the ingredients in formulations are often not specified. These may be trade secrets. Typical values for black and colored inks are given in Table 2.

Table 2: Typical Values for Printing Inks (US Ink 2000; Frank and Rupp 2012)

Component	Offset Black Ink	Water-based Colored Ink	Offset Colored Ink
Pigments	Carbon black: 17-20%	Organic pigments: 12-15%	Pigments and extenders: 20-35%
Resin	3-18%	10-25%	10-25%
Additives	1-5%	5-7%	1-5%
Carrier	Oils: 50-65%	Water: 53-73%	Oils: 30-45%

Specific Uses of the Substance:

Newspaper and other recycled paper are used as mulches to suppress weeds, retain moisture, moderate soil temperatures, and increase soil organic matter. They are also used as compost feedstocks, as plantable pots for vegetable starts, and as casings for mushroom beds.

Approved Legal Uses of the Substance:

Paper mulches are not subject to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and are not subject to regulation as an herbicide by the EPA. They are considered inert ingredients of minimal toxicological concern, and as such are permitted for use with minimum risk (25(b)) pesticides that are exempt from registration (40 CFR 152.25(f), Table 2).

Similarly, composting is not subject to federal regulation. A number of states regulate the production and distribution of compost. Paper is not regulated as a feedstock *per se*, but contamination of the feedstock by heavy metals and/or uncompostable composites may be subject to state regulations.

The FDA regulates food grade paper and paperboard components as indirect food additives (21 CFR 176).

Action of the Substance:

Paper mulch smothers weeds, blocks sunlight and covers the soil (Munn 1992; Runham and Town 1995). As a compost feedstock, paper serves as a source of carbon that provides energy to composting organisms during the cellulose decomposition process (Minnich et al. 1979; Rynk et al. 1992). Paper mulch also moderates soil temperature fluctuations (Pellett and Heleba 1994).

Combinations of the Substance:

Paper is composited with a wide range of materials (Hagiopol and Johnston 2012). In addition to ink and glossy coatings, paper can be combined with adhesives, glues, asphalt, resins, rosins, polymers, waxes, softeners and binders. Resins used to increase wetting strength in paper bags and packaging may include urea, formaldehyde, melamine, polyamines, polysaccharides, polyisocyanates, polycarboxylic acids, polyethers and rosin (Hagiopol and Johnston 2012). Rosin used for papermaking is derived from tall oil fractionated during the pulping process, and is usually combined with aluminum sulfate, also called “papermaker’s alum” (Hubbe 2005). Rosin is also used as a sizing agent (Hagiopol and Johnston 2012).

Composited materials have long been a barrier to the expansion of paper recycling, including composting (Midwest Research Institute and Franklin Associates 1975; Borchardt 2006; Roberts 2007; Handke and Brenner 2014). The increased need to recycle these complex fibers has radically changed the paper industry (McDonough and Braungart 2010; Hagiopol and Johnston 2012).

ISRI has guidelines for substances prohibitive from recycling as well as specifications for grade. Prohibitive materials are defined by ISRI as:

> "a. Any materials which by their presence in a packing of paper stock, in excess of the amount allowed, will make the packaging unusable as the grade specified.
> b. Any material that may be damaging to equipment.
> c. All sorted recovered paper stock must be free of food debris, medical or hazardous wastes and poisonous or other harmful substances or liquids.
> d. Wax is a Prohibitive unless accepted and pre-approved by the Buyer" (ISRI 2013).

Animal derived glues (glutin) are among the oldest adhesives, but most modern adhesives are synthesized from polyvinyl, ethylene, or polyurethane (Onusseit et al. 2000). Adhesive compounds, like inks, are generally proprietary formulations. Inks, dyes, and toners are also generally proprietary substances that have a wide variety of formulations. Slimicides, bactericides and other biocides may be used in some paper manufacturing and on paper to control slime and prevent it from forming on the paper surface, including paper used as packaging in direct contact with food. Food-grade antimicrobials and their adjuvants used in packaging are regulated in the United States by the FDA (21 CFR 176.300).

Status

Historic Use:

Newspaper has long been used as a mulch in organic gardening and organic farming (Rodale 1961). Similarly, newsprint, cardboard and other waste paper have been used as feedstocks for compost applied to organic land going back to when the first state organic food regulations were promulgated in the United States (Minnich et al. 1979).

Organic Foods Production Act, USDA Final Rule:

Newspapers or other recycled paper are listed in the NOP regulations at §205.601(b)(2)(i) under "mulches" with the annotation "without glossy or colored inks," and at §205.601(c) under "compost feedstocks" with the annotation "without glossy or colored inks." Both listings were included in the Final Rule creating the NOP regulations on December 21, 2000 (USDA Agricultural Marketing Service 2000).

International

Canadian General Standards Board Permitted Substances List (CAN/CGSB-32.311-2015)

Under "Compost feedstocks" on Table 4.2, the annotation permits "paper yard waste bags which contain coloured ink," and prohibits "glossy paper; waxed cardboard; paper containing coloured ink other than paper yard waste bags" (CAN/CGSB 2015).

Under "Mulches" on Table 4.3, the annotation permits newspaper and paper mulch and prohibits "glossy paper and coloured ink" (CAN/CGSB 2015).

Under "Cardboard" on Table 4.2, the annotation allows for its use as a mulch or compost feedstock but requires that it "shall not be waxed or impregnated with fungicide or prohibited substances" (CAN/CGSB 2015).

CODEX Alimentarius Commission, Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods (GL 32-1999)

Paper was not found in Annex 1, Tables 1 or 2. The "Compost from plant residues" listing has no annotation, but paper is not explicitly considered a plant residue (FAO/WHO Joint Standards Programme 1999). Mulching is mentioned in Annex 1.A.6, but no subsequent guidance on acceptable mulches was found in Table 2 (FAO/WHO Joint Standards Programme 1999).

European Economic Community (EEC) Council Regulation, EC No. 834/2007 and 889/2008

Paper does not appear in Annex I (Fertilisers and Soil Conditioners) or Annex II (Plant Protection Products) of EEC Council Regulation 889/2008. The annotation on wood products prohibits chemically treated wood. One European Certification Body doesn't allow the use of paper as a compost feedstock because most forms would be chemically treated with bleaches, dyes, glues and other contaminants (Hathway 2016). The EU Expert Group for Technical Advice on Organic Production (EGTOP) acknowledged that paper mulches are an established organic practice and stated that "[b]iodegradable mulching materials should be allowed, as long as all components of them comply with the Reg. (EC) 889/2008 for fertilisation and soil conditioning" (EGTOP 2013).

Japan Agricultural Standard (JAS) for Organic Production

Paper does not appear in the Japanese Agricultural Standard for organic crop production (Japan MAFF 2000).

IFOAM – Organics International

Paper does not appear in either Appendix 2 (Fertilizers and Soil Conditioners) or Appendix 3 (Crop Protectants and Growth Regulators) of the IFOAM Standards (IFOAM 2014). Appendix 2 allows "urban composts and household wastes from separated sources which are monitored for contamination," but paper does not appear to fit in this category. Synthetic mulches must be removed and not incorporated into the soil, which would mean that paper mulch would be prohibited from decomposing in the soil (Katto-Andrighetto 2016).

Evaluation Questions for Substances to be used in Organic Crop or Livestock Production

Evaluation Question #1: Indicate which category in OFPA that the substance falls under: (A) Does the substance contain an active ingredient in any of the following categories: copper and sulfur compounds, toxins derived from bacteria; pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals; livestock parasiticides and medicines and production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleansers? (B) Is the substance a synthetic inert ingredient that is not classified by the EPA as inerts of toxicological concern (i.e., EPA List 4 inerts) (7 U.S.C. § 6517(c)(1)(B)(ii))? Is the synthetic substance an inert ingredient which is not on EPA List 4, but is exempt from a requirement of a tolerance, per 40 CFR part 180?

Newspaper and other recycled papers are considered production aids that work by exclusion or other non-toxic mode of action, similar to row covers.

Evaluation Question #2: Describe the most prevalent processes used to manufacture or formulate the petitioned substance. Further, describe any chemical change that may occur during manufacture or formulation of the petitioned substance when this substance is extracted from naturally occurring plant, animal, or mineral sources (7 U.S.C. § 6502 (21)).

Most paper is still produced from the pulping of wood. In the wood pulp processing, timber is debarked and cut into chips. These are mechanically ground and then digested (cooked) chemically using either a sulfite or an alkali process at elevated temperatures in pressure vessels or digesters (Johnson and Peterson 1974). While it is possible to make paper strictly by mechanical means without chemical additives, quantity and quality are limited, and virtually all paper is produced by a combination of mechanical and chemical treatments. The most prevalent chemical processes used to manufacture pulp for papermaking are (1) the sulfite process and (2) the sulfate or Kraft process. Either process can be used to produce paper (French et al. 1993).

The Kraft process has become the prevalent technology for pulping (Hubbe 2005). Wood chips are cooked in an alkaline solution, usually involving sodium hydroxide and sodium sulfide or polysulfide (Hagiopol and Johnston 2012). The lignin then undergoes a series of reactions that break it down into dissolved carbohydrates. The pulping, defibration and refining of the coarse pulps are wet processes. The pulps are then fractionated into different streams for different products, such as corrugated cardboard, Kraft paper, newsprint and office paper.

Various compounds such as sodium sulfite or sulfur dioxide are used to prepare an acid solution where the wood chips are cooked at high temperatures to break the lignin. The solution is then neutralized with a strong base, such as sodium hydroxide. The sulfite process creates lignin sulfonate as a by-product. Formaldehyde may be used with sodium hydroxymethylcellulose in the sulfiting process to reduce the cooking time and increase the yield (Nakano, Sumi, and Nagata 1973).

Paper recycling begins with shredding and pulping the recovered paper. The pulping process is more commonly a thermal process with closer to a neutral pH than the Kraft or sulfite processes. The pulp is de-inked and various other impurities are removed. The de-inking process involves raising the pH of the pulp solution, usually with sodium hydroxide, and the introduction of various surfactants that act as detergents to remove the ink from the microfibrils to which they are attached (Borchardt 2006). Enzymatic removal is relatively new, and is more often used with electrostatic printed paper to remove toner than to remove inks and dyes imprinted by traditional techniques. Depending on the end use, the pulp may be further whitened by the use of bleach. Hydrogen peroxide is becoming more common in its use to whiten recycled paper as chlorine bleaches are being phased out (Roberts 2007), but chlorine bleaches may still be used. Ferrous metals such as staples and paperclips are removed by magnets. Other recovered papers, including cardboard, will have adhesives, glues and waxes. These latter contaminants of the recycling process are known as 'stickies' (Borchardt 2006). Other impurities in the low-grade mixed stream may be various synthetic polymers such as cellophane, low-density polyethylene, polystyrene (Styrofoam), staples and paper clips.

Evaluation Question #3: Discuss whether the petitioned substance is formulated or manufactured by a chemical process, or created by naturally occurring biological processes (7 U.S.C. § 6502 (21)).

Paper is manufactured by a chemical process. Both the sulfite and Kraft processes involve a series of chemical reactions that disintegrate the complex macro-molecular structures found in lignin and hemi-cellulose (Hagiopol and Johnston 2012). The sulfite pulping process involves acid-base reactions over a broad pH range. Paper mill sludge is the product of an industrial chemical process. Bacterial digestion of paper mill sludge may be used to purify it from contaminants and pollutants, as well as to enhance recovery of fibers that may be returned to the papermaking process (Goel and Walker 1977).

Research to commercially produce cellulose from microorganisms, replace chemical pulping with fermentation by microorganisms, and use enzymatic activity to purify cellulose began in the 1990s (Brennan 1998; Hagiopol and Johnston 2012). Most organisms of interest are microfungi that aid with the wood decay process. These include *Trichoderma viride, T. reesei, T. konignii,* and *Aspergillus niger.* Enzymes that are used include cellulose, cellobiohydrolase, and xylanase. Efforts have been underway to genetically engineer these and other organisms to increase the production efficiency of biological pulping and make it competitive with chemical pulping (Meyer 2008). At the present time, such biological processes are still experimental, supplemental, or used for specialty processes.

Once the pulping process is complete, fibers are sorted into different grades and further refined; certain grades of secondary fibers may be bleached. Since the 1930s, the primary bleaching agent has been chlorine dioxide. However, there is a trend toward replacing chlorine bleach, substituting hydrogen peroxide, ozone, sodium dithionite, or formadine sulfinic acid (FAS) as agents instead of chlorine dioxide. Enzymatic bleaching processes are also being explored (Brennan 2000).

In recycling, paper is shredded and pulped. Sodium hydroxide is often added to the pulper to increase fiber swelling (Borchardt 2006). Newsprint and magazines are commonly pulped at a pH of 8-10, while office paper is pulped over a wider range, from 7-11 pH. Other chemical additives used in the pulping stage of the recycling process are bleaches, usually hydrogen peroxide, chelating agents such as ethylene diamine tetraacetic acid (EDTA) and diethylene pentamine tetraacetic acid (DPTA), and sodium silicate. EDTA and DPTA levels are generally in the 0.15-0.4% range (Borchardt 2006). A variety of surfactants are used to detach the inks from the fibers and get them to float. Enzymes are also used to promote de-inking

(Brennan 2000). Toner inks behave differently from print and pen inks, so different surfactants are employed depending on the source of the paper.

One by-product of paper recycling is de-inking sludge, also known as de-inking paper fiber. De-inking sludge consists of inks, pigments, fibers, fillers, adhesives and coating compounds (Hamm 2012). As such, the various non-biodegradable and elemental contaminants are concentrated in the sludge. De-inking sludge has been mostly landfilled or burned. However, it may be co-composted with sewage sludge or poultry litter (Charest and Beauchamp 2002), or directly applied to soil (Chantigny et al. 1999).

Cellulose can be produced by bacteria, as well as by plants. Microbial cellulose was first discovered in the 19th century, but has never been commercially feasible or competitive with cellulose from trees by the chemical pulping process. With the development of genetic engineering and the discovery of applications of nanotechnology, there is renewed interest in the production of bacterial cellulose (Siró and Plackett 2010). With advances in nanotechnology, nanofiber paper is being introduced into the marketplace. Nanofibrils provide paper with a greater surface area, making it more absorbent, with greater wet strength. The USDA is actively supporting the advancement of cellulose nanotechnology (Wegner and Jones 2006).

<u>Evaluation Question #4:</u> Describe the persistence or concentration of the petitioned substance and/or its by-products in the environment (7 U.S.C. § 6518 (m) (2)).

Paper by itself is biodegradable and does not persist or concentrate in the environment. Cellulose—the main component—is readily biodegradable. Hemicellulose and lignin are also biodegradable, but are more resistant to hydrolysis and take longer to decompose in the environment (Richard 1996). Some contaminants in the waste paper stream are more persistent than others.

Black ink, in general, has not been found to be persistent in previous reviews, but it is also recognized not to be 100% biodegradable (Cotner, Sideman, and Heckman 1995; ICF Consulting 2006). Soy ink is more biodegradable than mineral oil ink, but it too will have persistent components (ICF Consulting 2006). To the extent that some colored inks use heavy metals that are elemental contaminants, these would persist in the environment. The elemental contaminants contained in the inks do not decompose. While most inks do not contain heavy metals, some do. Because ink formulations are often proprietary and are highly variable, heavy metal content of printed paper can be determined only by analytical methods. Some states have regulations that limit the consolidated total metal content of lead, chromium, mercury and cadmium in a finished package to 100 parts per million (ppm) (TPCH 2016). These regulations are aimed at protecting the environment during the disposal of post-consumer waste. Chlorinated yellow dyes are also non-biodegradable (Hamm 2012).

<u>Evaluation Question #5:</u> Describe the toxicity and mode of action of the substance and of its breakdown products and any contaminants. Describe the persistence and areas of concentration in the environment of the substance and its breakdown products (7 U.S.C. § 6518 (m) (2)).

Paper as a mulch has a non-toxic mode of action, and controls weeds by smothering and exclusion. The cellulose decomposes into carbohydrates, which are then metabolized by soil organisms. Decomposition is temperature dependent (Zibilske 1997). Depending on how it is collected, paper and other compostable items in the MSW stream can be contaminated by a wide variety of substances—just about anything discarded can end up in compost feedstocks (Harrison and Richard 1992; Smith et al. 2015).

Various contaminants in the paper may either remain in the soil or be metabolized, depending on their biodegradability. LDPE and paraffin, for example, would remain in the soil and would not biodegrade to any measurable degree, while some animal-derived adhesives, such as glue, would decompose and be metabolized. Elemental contaminants—such as lead, hexavalent chromium, cadmium, and mercury—are toxic and would be persistent, accumulating over time with regularly repeated loading through mulch or compost (Elfving, Bache, and Lisk 1979).

Black inks are generally non-toxic (Rynk et al. 1992). Some of the alternatives to metal based dyes—such as azo- and anthraquinone-based dyes—are considered possible carcinogens (IARC 2014; Puvaneswari, Muthukrishnan, and Gunasekaran 2006). During the 1990s in the UK, the trend was for lead, mercury and cadmium in colored newsprint to decrease below the detection limit. On the other hand, the increased use of colored ink in newsprint leads to an increase in elemental barium (Ba) and copper (Cu) (Tucker et al. 2000).

With the growing concerns about endocrine disruption related to BPA, its low dose toxicity, and the way it can enter the bloodstream through the skin (Vom Saal et al. 2007), efforts are underway to find suitable replacements. Two are bisphenol F (BPF) and bisphenol S (BPS). These analogs of BPA appear to have *in vitro* estrogenic activity similar to BPA (Goldinger et al. 2015).

Evaluation Question #6: Describe any environmental contamination that could result from the petitioned substance's manufacture, use, misuse, or disposal (7 U.S.C. § 6518 (m) (3)).

The process of logging and tree production will have impacts on forest ecosystems. While only a small percentage of virgin pulp is produced from old growth forests, such harvesting practices remain an environmental concern (Roberts 2007). Trees act as a carbon sink, capturing greenhouse gas emissions. Deforestation results in the loss of carbon sequestration capacity that takes years to restore even when trees are aggressively replanted soon after harvest (Brown et al. 1996; Miles and Kapos 2008). Paper recycling mitigates the loss of greenhouse gas sequestration capacity, but the recycling process still is not carbon neutral.

Pulp and paper manufacturing has a history of being a heavy polluter of water and air. Effluents from paper manufacturing include the chemical treatments used in the pulping process, dyes, fillers and bleaches (Hamm 2012). Pulp and paper facilities are regulated in the United States as point sources of water pollution under the Clean Water Act. As such, they are required to obtain permits for the discharge of effluents into water, to limit those effluents according to the permit, and to be subject to monitoring and fines by the EPA [40 CFR 430]. The effluent limits are technology based. Some of the treatments and reaction products may be classified as toxic pollutants subject to the Toxics Release Inventory program of EPA, including dioxins and furans (U.S. EPA 2006). Heavy metals are also discharged into water. In most years, pulp and paperboard manufacturing has been one of the top industrial sources of lead, cadmium and mercury released into Canadian water (Environment and Climate Change Canada 2016).

Pulp and paper mills generally use wood and waste paper as fuel, releasing carbon dioxide into the atmosphere and contributing to greenhouse gas emissions. In the United States, pulp and paper mills are considered stationary sources of air pollution and are subject to EPA regulation under the Clean Air Act [40 CFR 63]. In addition to greenhouse gases, paper mills also emit hazardous air pollutants (HAPs) that are generated as part of the pulping and chemical treatment of paper. The highest emitted HAPs from pulp and paper mills in 1996 were acrolein, acetaldehyde, o-cresol, carbon tetrachloride, chloroform, cumene, formaldehyde, methanol, methylene chloride, methyl ethyl ketone, phenol, propionaldehyde, 1,2,4-trichlorobenzene, and o-xylene (U.S. EPA 2001). The HAPs are produced by both the sulfite and Kraft processes, as well as by various treatments such as bleaching. The printing industry is also one of the top emitters of volatile organic compounds in the United States (Miller 2008).

Recycling paper reduces but does not eliminate the pollution and environmental degradation caused by paper manufacturing (Abramovitz, Mattoon, and Peterson 1999; Borchardt 2006; Roberts 2007; Hamm 2012). Commingled recycling increased participation in curbside collection programs in numerous cities in the UK, and has particularly increased newspaper recycling (Woodard et al. 2006). However, commingled recyclable materials are of much lower quality (Miranda 2013).

Pulp and paper mill sludge from primary, secondary, and de-inking processes is considered a growing environmental problem. In some paper producing areas, landfilling the sludge is becoming prohibitively expensive, and it is banned in some jurisdictions where landfill space is limited (Faubert et al. 2016). Composting and mulching are two of several alternatives to landfilling, with others being pyrolysis, and indirect energy production by production of bioethanol.

The petitioned use is an alternative to landfill disposal of paper. Thus, paper used as a compost feedstock and mulch are regarded by environmental and conservation authorities as an environmental benefit (U.S. EPA 2016b; USDA NRCS 2016). This view is shared from an international perspective (Garg et al. 2009; Hamm 2012).

<u>Evaluation Question #7:</u> Describe any known chemical interactions between the petitioned substance and other substances used in organic crop or livestock production or handling. Describe any environmental or human health effects from these chemical interactions (7 U.S.C. § 6518 (m) (1)).

The cellulosic fiber portion of paper is not biologically active, and there was no evidence found in the medical or scientific literature to suggest any adverse environmental or human health effects from the application of paper. The paper contaminants identified by the National List annotation of concern—glossy paper and colored ink—have documented adverse environmental and human health consequences that are explained further in Evaluation Questions #9 and #10.

<u>Evaluation Question #8:</u> Describe any effects of the petitioned substance on biological or chemical interactions in the agro-ecosystem, including physiological effects on soil organisms (including the salt index and solubility of the soil), crops, and livestock (7 U.S.C. § 6518 (m) (5)).

Paper is a source of carbon, which is used as an energy source by soil organisms. There is no salt index published for paper. Because paper by itself is insoluble and non-ionic, the salt index can be reasonably expected to be zero. However, paper additives may contribute to salination.

Multiple applications of paper mill sludge over a five-year period in Maine was found to increase soil carbon and organic matter content, as well as soil moisture holding capacity (Zibilske et al. 2000). The authors concluded that paper mill sludge has the potential to elicit positive changes in several soil properties.

Paper in compost and mulch appears to have a beneficial effect on at least some soil organisms. For example, paper was observed to increase the actinomycetes colonization of compost when compared with vegetable waste as a feedstock (Finstein and Morris 1975). The same study noted that newspaper as a feedstock increases aeration and reduces clumping, both of which improve conditions for aerobic compost.

Earthworms have been used successfully to vermicompost paper (Short, Frederickson, and Morris 1999; Arancon et al. 2003; Arancon et al. 2005; Frederickson, Howell, and Hobson 2007; Ali et al. 2015). The earthworm *Eisenia foetida* was fed combinations of food waste, manures, sludges and paper. Paper by itself had a relatively high C:N ratio to support weight gain and reproduction. Optimal growth was in C:N ratios in the range of 15:1 to 35:1 (Neuhauser et al. 1980). Because earthworms accumulate some metals, vermicomposting has been proposed as a way to reduce potentially toxic elements in compost made from waste paper (Frederickson et al. 2007). Pulp and paper waste was also found to be relatively benign to earthworms and other soil organisms. In some cases, the solid waste material enhanced the growth of plants, earthworm reproduction, and microbial respiration (Fraser, O'Halloran, and Van Den Heuvel 2009).

In one experiment, sheep that were fed newspapers and magazines that had an average lead content of 514 ppm. The researchers found that the Pb in the sheep brains more than doubled, while the Pb passed in the sheep feces increased by 16- to 18-fold over a control diet without paper (Heffron et al. 1977). The USDA's Natural Resource Conservation Service (NRCS) recognizes that mulch—including newspaper mulch—protects the soil from erosion, reduces compaction from the impact of heavy rains, reduces the need for frequent watering, prevents weed growth, and maintains an even soil temperature, among other benefits to the soil and agro-ecosystem (USDA NRCS 2016). In its recommendations on mulch, the NRCS states: "Only use newspaper text pages (black ink); color dyes may be harmful to soil microflora and fauna if composted and used" (USDA NRCS 2016). Azo dyes, which have been developed as alternatives to some of the metal based dyes, are biodegradable by several species of bacteria (Puvaneswari, Muthukrishnan, and Gunasekaran 2006). However, chlorinated yellow dyes are non-biodegradable (Hamm 2012).

<u>Evaluation Question #9:</u> Discuss and summarize findings on whether the use of the petitioned substance may be harmful to the environment (7 U.S.C. § 6517 (c) (1) (A) (i) and 7 U.S.C. § 6517 (c) (2) (A) (i)).

Paper, by itself, is not known to be harmful to the environment. If the original source of cellulose is taken into account, then the environmental impacts of logging need to be considered. Natural ecosystems have been cleared and replaced with plantations of fast-growing species harvested for paper, threatening biodiversity (Roberts 2007). Genetically engineered trees have been commercially released in China for the purpose of producing paper and other cellulose products (FAO 2004). Their release has raised environmental concerns, particularly with biodiversity loss and genetic drift to related species (El-Lakany 2004). Transgenic trees are expected to contribute to cellulose production in the United States in the near future (Roberts 2007). Recycling and the planting of alternative paper crops would mitigate the impact of cellulose manufacturing on biodiversity (Roberts 2007).

Inks, coatings and other paper additives are documented to have environmental impacts. The Coalition of Northeastern Governors (CONEG) regarded the heavy metals in packaging to pose hazards to public health and safety, and to the environment. Paper products make up the largest part of this stream. To address this problem, CONEG prepared draft model legislation that limited the amounts of cadmium, lead, mercury, and hexavalent chromium in packaging (TPCH 2012). As of October 2016, the following states have adopted laws that limit these toxic substances in packaging: California, New York, New Jersey, Washington, Iowa, Minnesota, Connecticut, New Hampshire and Rhode Island (TPCH 2016).

<u>Evaluation Question #10:</u> Describe and summarize any reported effects upon human health from use of the petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (i), 7 U.S.C. § 6517 (c) (2) (A) (i)) and 7 U.S.C. § 6518 (m) (4)).

No incidents of direct adverse human health effects caused by paper used as a mulch or compost feedstock were found when searching the scientific and medical literature. The current annotation restricting the types of paper used was based on incidents related to secondary exposure to heavy metals—particularly lead—used in colored inks. Paper fiber is linked to occupational risks of adverse health effects—particularly inhalation of particulate matter in paper mills, and with the processing of recycled paper products—but none of these incidents were linked to the specific applications related to organic farming: mulching and composting.

Secondary effects related to the additives used in paper have been the subject of study. Exposure of children to lead is a public health concern because it can cause irreversible neurological damage during the development of fetuses, infants and young children. Hexavalent chromium (Cr-VI) in lead chromate is reported as a known human carcinogen (NTP 2011). Pediatricians reported lead intoxication from children who chewed on colored paper (Hankin et al. 1973). The use of lead chromate in colored ink used for the publication of children's magazines was specifically identified as a risk in the 1970s (Eaton et al. 1975). Subsequent findings showed that leaded inks were common in printed matter in the United States, with some sources having over 1,000 ppm of Pb where 100 ppm posed a considerable lead burden when ingested (Sohler and Pfeiffer 1977).

Human exposure to lead through colored paper applied as mulch was also identified as a potential human health concern. Colored paper with 567 ppm of lead and a control of bond paper with 0.2 ppm of lead were applied to two different soils in containers, one with a pH of 5.6 and the other with a pH of 7.2 over a period of two years (Elfving et al. 1979). The treatment resulted in small but significant increases of lead uptake by beans, cabbages, carrots, onions, potatoes, and tomatoes, as well as millet seed and straw, and apple leaves and twigs. Uptake was slightly greater with the lower pH, but not consistently pH dependent. The authors concluded that accumulation would increase over time with repeated incorporation of colored paper mulches into the soil. USDA and extension personnel recommended using newspaper pages, but not advertising circulars or magazines to avoid Pb and Cr (Chaney et al. 1984).

While the United States and many other countries have banned lead and hexavalent chromium from being used as pigments in food-grade packaging, not all countries have. Scientists investigated the levels of the heavy metals copper, cadmium, lead, hexavalent chromium, manganese, cobalt and zinc found in wrappers of candy sold in South Korea (Kim et al. 2008). The packaging for candy manufactured in South Korea was found in some samples to carry significant levels of both lead and hexavalent chromium. Candy wrappers from China had significant levels of cadmium, lead and hexavalent chromium. The two samples of candy from the United States had no detectable levels of lead, cadmium or hexavalent chromium. Even in countries where these substances have been banned, amounts above the legal limits are sometimes detected (Conti et al. 1996; Conti 1997). In paper products manufactured for non-food uses, as well as food products imported from countries that do not have equivalent restrictions on food packaging, inks still pose a risk.

No human health risks were identified from the various glosses, coatings and laminates that are applied to 'glossy' paper, either as a primary risk through direct ingestion or as a secondary risk through the soil.

Evaluation Question #11: Describe all natural (non-synthetic) substances or products which may be used in place of a petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (ii)). Provide a list of allowed substances that may be used in place of the petitioned substance (7 U.S.C. § 6518 (m) (6)).

Alternative nonsynthetic carbon-rich compost feedstocks include sawdust, wood shavings, straw, hay and leaves. With a C:N ratio of 398-852, newsprint has one of the highest C:N ratios (Rynk et al. 1992). Sawdust and wood shavings are nonsynthetic and have comparable C:N ratios, but they take longer to decompose. Newspaper has higher water holding capacity than straw. Recycled newspaper used in an experiment that looked at newspaper used as dairy bedding had 4.35 ppm Cr, 0.89 ppm Pb, and 0.12 ppm Cd, many times higher in every case than the same heavy metals found in straw (Ward et al. 2000).

Other mulches recommended for vegetables include grass clippings, leaves, pine needles and straw (Jauron 2013). Grass clippings may form a dense mat. Also, lawn clippings treated with a broadleaf herbicide may kill vegetable crops. Leaves and pine needles may lower soil pH to a greater extent than paper. Pine needles also may take longer to decompose than paper. Straw may provide a winter habitat for mice and other rodents. Plastic mulch may also be used, provided it is not made with polyvinyl chloride (PVC) [7 CFR 205.601(b)(2)(ii)]. Biodegradable plastic mulch may be used, provided it is produced without organisms or feedstocks derived from excluded methods [7 CFR 205.601(b)(2)(iii)].

Paper mulch has outperformed plastic mulch for weed suppression in several experiments comparing the two (Bond and Grundy 2001). Paper mulch was as effective as wheat straw in managing weeds in corn and soybeans grown over two years in Wisconsin (Munn 1992).

Evaluation Question #12: Describe any alternative practices that would make the use of the petitioned substance unnecessary (7 U.S.C. § 6518 (m) (6)).

The alternative carbon-rich feedstocks for compost are described in Evaluation Question #11. Besides compost made from the alternative carbon sources mentioned there, the main alternative practice to increase soil carbon would be growing cover crops in rotation.

Alternative practices to paper mulch include cultivation, living mulches, hand weeding, flame weeding, crop rotation, and biological control of weeds (Liebman and Davis 2000; Bond and Grundy 2001; Baker and Mohler 2014). Mulching with the other mulches described in Evaluation Question #11 would also be an alternative.

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