

Activated Charcoal

Livestock

Executive Summary

Activated carbon was petitioned for veterinary use, principally to remove toxins. It is considered to be the universal poison antidote. Carbon is obtained from a wide variety of sources and is activated by a number of different processes. The reviewers all considered activated carbon in general to be synthetic. All recommended that it be allowed for use in organic production with restrictions. These restrictions would limit it to therapeutic use and prohibit routine feeding in the absence of poisoning.

Summary of TAP Reviewer's Analyses¹

<i>Synthetic/ Nonsynthetic</i>	<i>Allow without restrictions?</i>	<i>Allow only with restrictions?</i>	<i>Prohibit for all uses</i>	<i>Prohibit with Limited Uses</i>
Synthetic (2) Non-synthetic (1)	Yes (0) No (3)	Yes (2) No (1)	Yes (0) No (3)	Yes (1) No (2)

Identification

Chemical Names:

Carbon, Activated

Other Name:

Activated charcoal; Active carbon; Active charcoal;
Amorphous carbon; Bone black; Bone coal; Channel
black; Charcoal; Decolorizing carbon; Lamp black

Trade Names:

Calgon, MedChar, Superchar Vet, Toxiban,

CAS Numbers:

7440-44-0; 64365-11-3

Other Codes:

EINECS No.: 231-153-3

ECL Serial No.: KE-04671

Characterization

Composition:

Carbon arranged in a quasi-graphitic form in a small particle size.

Properties:

A solid, porous, black carbonaceous material. Tasteless (Budavari, 1996). Activated carbon is distinguished from elemental carbon by the removal of all non-carbon impurities and the oxidation of the carbon surface (Mattson and Mark, 1971).

How Made:

Activated carbon can be prepared from a large number of sources by a wide variety of methods. The Merck Index divides these into four basic forms: *Animal charcoal* is obtained by charring bones, meat, blood, etc.; *Gas black, furnace black, or channel black* is obtained by the incomplete combustion of natural gas; *Lamp black* is obtained by the burning various fats, oils, resins, etc., and *Activated charcoal* is prepared from wood and vegetables (Budavari, 1996).

¹ This Technical Advisory Panel (TAP) review is based on the information available as of the date of this review. This review addresses the requirements of the Organic Foods Production Act to the best of the investigator's ability, and has been reviewed by experts on the TAP. The substance is evaluated against the criteria found in section 2119(m) of the OFPA [7 USC 6517(m)]. The information and advice presented to the NOSB is based on the technical evaluation against that criteria, and does not incorporate commercial availability, socio-economic impact, or other factors that the NOSB and the USDA may want to consider in making decisions.

47 Activated carbon can be produced from a number of agricultural commodities. Among these are hardwoods, grain hulls,
48 corncobs, and nutshells (Young, 1996). Steam activation can also be used with food-grade carbonaceous material (Burdock,
49 1997). Acid treatment is also common. For example, pecan shells can be activated by treatment with hydrochloric acid, then
50 heated in an electric furnace for four hours at 800-1,000°C. in an atmosphere of carbon dioxide (Young, 1996).

51
52 There is some disagreement among various sources as to whether bone char or bone black should be considered an 'active
53 carbon.' Mantell (1968) devotes an entire chapter to bone char, noting that it contains between 9-10% adsorbent carbon when
54 prepared. Smíšek, and Cerný (1970) dismiss bone char as a form of active carbon because it is predominately composed of
55 calcium phosphate, and notes that many of its properties—particularly its capacity to decolorize sugar and other sweeteners—is
56 related to this heterogenous chemical composition. It is included in this review because of its historical and commercial
57 importance. Bone char is prepared by the removal of all flesh, fat, and oil. After their adsorptive capacity is spent, bone char can
58 be mechanically and physically regenerated through drying and pricking with hot rods (Elmenhorst, 1880).

59
60 Among the other raw materials used as precursors to make activated carbon are sawdust, peat, lignite, coal, cellulose residues
61 (Lambiotte, 1942), and petroleum coke, spent ion exchange resins such as styrene-divinyl benzene polymers (von Blucher and De
62 Ruitter, 1999), phenol-formaldehyde resins (Teng and Wang, 2000), and old automobile tires (Whitaker and Grindstaff, 1974;
63 Sang, 1975; Teng, et al., 1999), and sewage sludge (Kermmer, Robertson, and Mattix, 1972; Nickerson and Messman, 1975;
64 Sutherland, 1976). Various binding agents may be added to improve the structure (Baker et al., 1992). Commercial sources appear
65 to be made from a variety of precursors, activating agents, and binders (Tolles, et al, 1993; Ashford, 1994; Ivey and Hoffman,
66 1998)

67
68 Any given carbon sources may be prepared, treated, or manufactured by a wide variety of methods. These may or many not
69 involve synthetic acids, bases, and other substances in a stream of activating gases such as steam (H₂O), nitrogen (N₂) or carbon
70 dioxide (CO₂). Yields and quality can be improved by the removal of moisture (UN FAO, 1985). Lignite and peat are made into
71 activated charcoal by low-temperature charring, followed by treatment with either superheated steam or potassium hydroxide.
72 Cation-exchange resins can be made by sulfonation, or by nitration and reduction. Treatment of low-rank coal with ethylene
73 dichloride and ammonia gives an anion exchange resin (Vorres, 1996). Some processes treat carbonaceous matter with
74 phosphoric acid and / or zinc chloride (Krczil, 1937), with the resulting mixture carbonized at an elevated temperature, followed
75 by the removal of the chemical activating agent by water washing (Food Chemicals Codex, 1996).

76
77 Activated carbon can be recycled, reactivated, or regenerated from spent activated carbon. Activated carbon used to treat
78 hazardous waste or that becomes concentrated with adsorbed hazardous chemicals can be considered hazardous waste itself.

79 80 **Specific Uses:**

81 The petitioned and principal veterinary use is as an antidote to toxic substances—and analogous medical applications
82 include use as a detoxifier. It is regarded as the poison antidote of choice (Aiello, 1996) and the universal antidote to toxic
83 substances (Kanzler, 1995). There is no reported overdosage or acute toxicity (Plumb, 1999). Activated charcoal is highly
84 effective against both natural and synthetic toxins (Aiello, 1996). Studies show activated carbon to be effective in removing
85 various mycotoxins, such as aflatoxin, fumonisins, ochratoxin A, trichothenes, and zearalenone (Dalvi and Ademoyero,
86 1983; Rotter et al., 1989; Kubena, et al., 1990; Edrington, et al., 1997; Huwig, et al., 2001). Natural toxins from plants are
87 also removed or attenuated by activated charcoal treatment or supplementation (Pass and Stewart, 1984; McLennan and
88 Amos, 1989; Poage et al., 2000; Banner, et al., 2000; Bisson, et al., 2001). Activated carbon can also be used to remove
89 synthetic pesticides from animals that might contaminate milk or meat (Cook and Wilson, 1971; Morgan et al., 1977;
90 Aiello, 1998). Treatment with activated carbon when using certain parasiticides can help reduce the residual levels in flesh
91 and fatty tissue (Crookshank, et al., 1972). Finally, activated charcoal is used to treat animals for drug overdoses (Haddad
92 and Winchester, 1983), with efficacy established on pigs (Lipscomb and Widdop, 1975), dogs (Widdop et al., 1975), and
93 rabbits (Galloway and Liu, 1981).

94
95 Pharmaceutical production accounts for about 6% of liquid phase activated carbon consumption (Baker, et al., 1992).
96 Most of this is used for the purification of various fermentation broths that have been solvent extracted. Use as a food and
97 beverage production is covered in a separate TAP review. Activated charcoal is used in agriculture as a soil amendment
98 (e.g. alkali-treated humates and humic acid derivatives), and as a component of nursery or transplant media (Wellen, et al.,
99 1999), as well as to remove pesticide residues (McCarty, 2002). Among the literally hundreds of other uses are agents in
100 gas masks; pollution control devices such as car catalytic converters and flue gas desulfurization (Ashford, 1994).

101 102 **Action:**

103 Activated carbon has an extraordinarily large surface area and pore volume that gives it a unique adsorption capacity
104 (Baker, et al., 1992). Commercial food grade products range between 300 and 2,000 m²/g (Burdock, 1997). Some have
105 surface areas as high as 5,000 m²/g. The specific mode of action is extremely complex, and has been the subject of much
106 study and debate. Activated carbon has both chemical and physical effects on substances where it is used as a treatment
107 agent. Activity can be separated into (1) adsorption; (2) mechanical filtration; (3) ion exchange; and (4) surface oxidation.

108
109 Adsorption is the most studied of these properties in activated carbon. Most applications of activated carbon can be
110 characterized by the adsorption that occurs when components of a liquid (the poison) attaches to a solid (activated
111 carbon). This can be either physical or chemical in nature, and frequently involves both. Physical adsorption involves the
112 attraction by electrical charge differences between the adsorbent and the adsorbate. Chemical adsorption is the product of
113 a reaction between the adsorbent and the adsorbate.

114
115 Adsorption capacity depends on

- 116
117 a) physical and chemical characteristics of the adsorbent (carbon);
118 b) physical and chemical characteristics of the adsorbate (the food or beverage);
119 c) concentration of the adsorbate in liquid solution;
120 d) characteristics of the liquid phase (e.g. pH, temperature)
121 e) amount of time the adsorbate is in contact with the adsorbent (residence time).

122
123 (Cheremisinoff and Morresi, 1978).

124
125 Mechanical filtration involves the physical separation of suspended solids from a liquid passing through carbon arrayed as
126 a porous media in a column or bed. Any finely divided solid—such as sand or cellulose—can accomplish this. While this
127 accounts for some of the clarification properties of carbon, it is seldom the sole reason for the selection of carbon as a
128 clarification medium. The effectiveness of filtration depends on particle size, bulk density, and hardness (Ahmedna et al.,
129 2000). While a smaller particle size results in a clearer liquid, it also slows the speed of processing. Bulk density determines
130 how much carbon can be contained in a given container. Hardness matters because the particles need to have sufficient
131 strength to block the particulate matter being filtered.

132
133 Ion exchange is defined as a ‘reversible chemical reaction between a solid and an aqueous solution that allows the
134 interchange of ions . . .’ (Ockerman, 1991). Coal is a natural ion exchanger (Helfferich, 1962). Ion exchange can be
135 enhanced by chemical activation. Carbon surfaces have both negative (anionic) or positive (cationic) charges to attract free
136 ions in solution or suspension, depending on how they are treated. Treatment of carbon with a base increases the capacity
137 of carbon to exchange anions; acidulation of the surface makes carbon a powerful cation exchanger (Jankowska, et al.
138 1991).

139
140 Surface oxidation involves the chemisorption (=chemical adsorption) of atmospheric oxygen to the carbon and the further
141 reaction of the surface oxides that chemically react with other substances that are oxidized. The surface of activated
142 carbon has an electrical double layer (Mattson and Marks, 1971).

143
144 Activated carbon removes the poison from the skin or alimentary tract by all of these methods, and is then shed or
145 excreted (Radostits, et al., 2000).

146 147 **Combinations:**

148 Activated charcoal for veterinary purposes is generally pharmaceutical (USP) grade. It is complexed with kaolin clay (bolus
149 alba), propylene glycol, and various unspecified wetting and dispersing agents (Kanzler, 1995). Among the wetting agents
150 and dispersants used are naphthalene sulfonates, alkyl aryl polymers, and triethanolamine (Rockwell, 1939). Alternative
151 formulations may use other clays and mined minerals such as bentonite and gypsum; synthetically treated minerals such as
152 dicalcium phosphate and silica gels; vegetable gums; synthetic vegetable derivatives such as sodium
153 carboxymethylcellulose; solvents such as isopropanol; and synthetic suspension polymers such as povidone (Kollidon)
154 (Adler, 1926; Manes, 1975; Vet-a-mix 1995; Bühler, 1998). Injectable carbon may employ a saline solution, sugars such as
155 dextrose and glucose, and vegetable gums (Rockwell, 1939).

156 157 **Status**

158 **Historic Use:**

159 Charcoal dates back to the prehistoric discovery of fire. The Egyptians used charcoal as a topical antidote to poisoning
160 (Yehaskel, 1978). Ancient Hindus filtered their water with charcoal (Cheremisinoff and Ellerbusch, 1978). Scheele
161 discovered the fact that certain types of charcoal had adsorptive capacity—were chemically ‘active’—in 1773. Charcoal
162 was found to decolor tartaric acid in 1785. In 1794, charcoal was first applied to the refinement of sugar (Jankowska, et al.,
163 1991).

164
165 By 1901, scientists had developed ways to synthesize activated carbon from coal carbon that had equivalent or superior
166 adsorptive and decolorizing capacity to bone black (Smíšek, 1970). These methods were soon introduced to the US
167 (Richter 1911). Use for removal of taste and odor from municipal water supplies in the US began about 1929 (Burdock,
168 1997).

169
170 While the detoxifying effects of activated charcoal have long been documented, optimization of dosage and delivery did
171 not begin in earnest until the 20th century. Excipient packages became refined in the 1920s (Adler,1926). Injectable
172 solutions were made practical in the 1930s (Rockwell, 1939). More recent developments have focused on palatability
173 (Manes, 1975).

174
175 **OFPA, USDA Final Rule:**

176 Activated carbon does not appear anywhere in the OFPA or NOP Final Rule. However, humic acid derivatives (7 CFR
177 205.601(j)(3) are usually composed of alkali treated lignite coal, and can thus be considered a form of activated carbon
178 (Vorres, 1996).

179
180 **Regulatory: EPA/NIEHS/Other Sources**

181 **USEPA:**

182 Activated carbon does not itself appear on any of the lists of hazardous substances (US EPA, 1998). However, given that
183 it is used to remove toxic substances from potable water, wastewater treatment, and hazardous waste effluent, spent
184 activated carbon contaminated with toxic substances removed from these production streams can be considered
185 hazardous waste and fall under the EPA's authority under the Resource Conservation and Recovery Act's jurisdiction (40
186 CFR 264(x); Shapiro, 1996). For the most part, the regulations applied to food processors involve activated carbon as an
187 effluent treatment system for wastewater (US EPA, 1998a).

188
189 Carbon is registered as an active pesticide ingredient (54 Fed. Reg. 7440; 54 Fed. Reg.22706; 54 Fed. Reg. 30848; 54 Fed
190 Reg. 4388; 55 Fed. Reg. 31164) and is used as an inert ingredient in pesticides and appears on EPA Inerts List 4B (US
191 EPA, 1995).

192
193 **NIEHS:** Does not appear in the National Toxicology Program database (NTP, 2002).

194
195 **FDA:**

196 Approved as a drug for over-the-counter (OTC) use in humans (21 CFR 310.545(a)(8)).

197
198 The only listing found in EAFUS for activated carbon (accessed July 12, 2002) is at 21 CFR 177.1210. This addresses
199 substances for use as basic components of single and repeated use food contact surfaces. Specifically, activated carbon is
200 permitted to form up to 1% of a closure with sealing gaskets for food containers. Activated carbon is also mentioned in
201 the ion exchange section (21 CFR 173.25).

202
203 **OSHA:**

204 The Occupational Safety and Health Administration's OSHA Permissible Exposure Levels (PELs) for synthetic graphite
205 (activated carbon) are:

206 (Total dust): 15 mg/m³

207 (Respirable fraction): 5 mg/m³

208 Source: 29 CFR 1910.1000.

209
210 **DOT:**

211 Activated carbon appears on the US Department of Transportation's Hazardous Materials Table because it is
212 spontaneously combustible

213 Source: 59 Fed. Reg. 67395.

214
215 **AAFCO:**

216 The official feed term includes both plant and animal derived sources (AAFCO, 2002).

217
218 **Status Among U.S. Certifiers**

219 Not listed in any published standards.

220
221 *California Certified Organic Farmers (CCOF)* – CCOF Manual Two: USDA Requirements For Organic Producers (Dec. 2001)
222 not listed.

223
224 *Oregon Tilth Certified Organic (OTCO)* – Oregon Tilth Certified Organic Standards, Oct. 8, 2001. Not listed in Section 8,
225 National List that accompanies the standards.

226
227 *Organic Crop Improvement Association International (OCIA)* OCIA Standards Manual NOP Standards plus OCIA International
228 Requirements 2002: not listed

229

230 *Quality Assurance International (QAI)* – No reference.

231

232 *Texas Department of Agriculture (TDA) Organic Certification Program* – TDA Organic Certification Program Materials List
233 (February 2000) not listed

234

235 *Washington State Department of Agriculture (WSDA) Organic Food Program* – Chapter 16-158-060 WAC (rev. January 18, 2001),
236 not listed.

237

238 **International**

239 22. CODEX – Part B, Section 22 states that the “use of veterinary medicinal products in organic farming shall
240 comply with the following principles:

241 a) “where specific disease or health problems occur, or may occur, and no alternative permitted treatment or
242 management practice exists, or, in cases required by law, vaccination of livestock, the use of parasiticides, or
243 therapeutic use of veterinary drugs are permitted;

244 b) “phytotherapeutic (excluding antibiotics), homeopathic or ayurvedic products and trace elements shall be used in
245 preference to chemical allopathic veterinary drugs or antibiotics, provided that their therapeutic effect is
246 effective for the species of animal and the condition for which the treatment is intended;

247 c) “if the use of the above products is unlikely to be effective in combating illness or injury, chemical allopathic
248 veterinary drugs or antibiotics may be used under the responsibility of a veterinarian; withholding periods
249 should be the double of that required by legislation with, in any case, a minimum of 48 hours;

250 d) “the use of chemical allopathic veterinary drugs or antibiotics for preventative treatments is prohibited.

251

252

253 EU 2092/91 – Annex I, Part B, Section 5 states that the “use of veterinary medicinal products in organic farming shall
254 comply with the following principles:

255 (a) “Phytotherapeutic (e.g. plant extracts (excluding antibiotics), essences, etc.), homeopathic products (e.g. plant, animal
256 or mineral substances) and trace elements and products listed in Part C, section 3 of Annex II, shall be used in
257 preference to chemically-synthesised allopathic veterinary medicinal products or antibiotics, provided that their
258 therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended;

259 (b) “If the use of the above products should not prove, or is unlikely to be, effective in combating illness or injury, and
260 treatment is essential to avoid suffering or distress to the animal, chemically-synthesised allopathic veterinary
261 medicinal products or antibiotics may be used under the responsibility of a veterinarian;

262 (c) “The use of chemically synthesised allopathic veterinary medicinal products or antibiotics for preventive treatments is
263 prohibited.”

264

265 Activated charcoal does not appear on the list of feed materials allowed in Annex II, Part C.

266

267 IFOAM – The use of conventional medicines is allowed when no other justifiable alternative is available.

268

269 Canada – Not listed in Appendix B—Permitted Substances List for Livestock Production

270

271 **Section 2119 OFPA U.S.C. 6518(m)(1-7) Criteria**

272

273 1. *The potential of the substance for detrimental chemical interactions with other materials used in organic farming systems.*

274 For the most part, activated carbon will interact to adsorb and neutralize other materials used in organic farming
275 systems. Any detrimental interaction would result from the concentration of these substances. Generally,
276 concentration would be in the feces of the treated animals. Proper manure management and composting should be
277 able to mitigate or eliminate the detrimental chemical interactions resulting from treatment.

278

279 2. *The toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of
280 concentration in the environment.*

281 Activated charcoal itself is regarded as an effective treatment for poisoning. Carbon is elemental in form. However,
282 many applications will concentrate the toxic substances that it removes and captures, thus becoming toxic itself.

283

284 3. *The probability of environmental contamination during manufacture, use, misuse, or disposal of the substance.*

285 Environmental contamination depends on the source. Most—but not all—sources indicate that they are vegetable
286 derived. Medicinal charcoals have long had product specifications that require only the highest purity vegetable
287 source. In some cases the species of plant is named, with corresponding analytical methods developed for quality
288 assurance purposes (Paulssen, 1964; Mantell, 1968). However, it is possible for any source to be used provided it

meets USP grade. That would include coal, petroleum, and polymer derived sources. A review of the environmental impacts of the manufacturing from these sources is beyond the scope of the review, but is deemed by the reviewers to pose a significant probability of environmental contamination. At least one older reference indicates that bone may be a source of pharmaceutical activated charcoal (Haddad and Winchester, 1983).

In general, the charcoal is passed through the animal and excreted in manure. While the toxins are concentrated in the manure, properly handled manure should not constitute any greater contamination risk than manure from conventional farm sources.

4. *The effects of the substance on human health.*

Can cause respiratory problems to those who handle it, especially as particle size decreases. Inhalation causes cough, dyspnea, black sputum, and fibrosis (Patnaik, 1992). There is also a potential for it to spontaneously combust and incomplete combustion produces carbon monoxide (Cheremisinoff, 1999).

5. *The effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock.*

A number of studies indicate that activated charcoal can be used as a feed supplement to stimulate feeding on unpalatable or poisonous plants (Banner, et al., 2000; Poage, et al., 2000; Bisson, et al., 2001).

Carbon is necessary for soil organisms. Application to soil has been shown to bind and reduce the availability of a number of antimicrobials in the soil (Tolls, 2001).

The effects of the substance on livestock are largely beneficial. Activated charcoal reduces suffering and saves many lives of animals (Buck and Bratich, 1986). There are few contraindications or situations where treatment would be life threatening. Treatment may result in dehydration (Kanzler, 1995).

6. *The alternatives to using the substance in terms of practices or other available materials.*

Most organic farmers would avoid the chemical and allopathic poisons that are the primary reasons for using activated charcoal because these substances are prohibited. In cases of accidental or incidental contamination, there are a number of poison antidotes that are used as alternatives: water, milk, saline (sodium chloride) solution, but activated charcoal is preferred in most situations (Aiello, 1998). One current veterinary reference declares activated charcoal to be the only effective adsorbent (Radostits, et al., 2000). For use to prevent or avoid mycotoxins in feed, various minerals, such as aluminosilicates and bentonite appear to be effective (Kubena, et al., 1990; Huwig, et al., 2001).

To avoid mycotoxins, better timing of harvest, improved handling, and better quality control can reduce *Aspergillus flavus* and other pathogens. Toxic plants can be avoided through range or pasture management methods that enhance non-toxic species, rotation, or decreased densities.

7. *Its compatibility with a system of sustainable agriculture.*

Therapeutic use for diagnosed poisons is compatible with the NOSB Principles of Organic Production and Handling (NOSB 2001), which state that organic production promotes animal health and welfare while minimizing stress. NOSB also states that organic producers should avoid the routine use of chemical allopathic veterinary drugs, including antibiotics. Non-routine use with alternative anthelmintics may be controversial. Use as a feed additive to increase the grazing of otherwise toxic crops could improve rangeland by the removal of these plants, but could also lead to overgrazing and depletion of range resources.

TAP Reviewer Discussion

Reviewer 1 [Veterinarian in the mid-south specializing in ovine and caprine animals]

“Use as a feed additive to increase the grazing of otherwise toxic crops could improve rangeland by the removal of these plants, but could also lead to overgrazing and depletion of range resources.” None of the references included made a strong case for the use of activated charcoal as a feed additive. Use as a feed additive also indicates routine use. Therefore, any reference in the TAP document for the use of activated charcoal as an additive for grazing of otherwise toxic crops should be omitted.

346 *Conclusion*

347 Activated charcoal should be a restricted non-synthetic prohibited because of its very important use in adsorption of toxic
348 substances. By categorizing it as a non-synthetic, this limits the processing to heating and combustion of naturally
349 occurring substances only. This would comply with NOSB's interpretation.

350
351 While the use of activated charcoal can create a potential environmental problem when bound with toxic substances, using
352 it in specific cases of ingestion of toxic substances would keep the toxic endproducts to a minimum. Use as a detoxifier
353 would have no toxic waste associated.

354
355 Organic livestock producers should have their management of the farm set up so that poisoning of livestock is a rare
356 occurrence. However, those producers should also have available to them a product that is natural, that is more effective
357 in some medical instances than alternatives, and which causes no harm to the environment when used for a very specific
358 instance. Listing it as a prohibited non-synthetic eliminates its use as a feed additive that would be routine and would force
359 livestock to graze plants that could be harmful and which they would not otherwise eat. This would not be compatible
360 with a sustainable system that should strive to manage noxious and poisonous plants by means harmless to livestock and
361 people.

362
363 *a. The substance is Not Synthetic*

364
365 *b. For Crops and Livestock, the substance should be Added to the National List only with an annotation that restricts*
366 *use. (List as Prohibited non-synthetic, restricted)*

367
368 (Note: Synthetic materials are added to the National List of Allowed Synthetics. Non-synthetic materials are added to the
369 National List of Prohibited Non-synthetics. Non-synthetics may be added to the Prohibited list with a restriction that
370 permits some uses.)

371
372 *Reviewer 2 [Research chemist on the East Coast who serves on a certification committee]*

373 *Material and manufacturing*

374 Activated carbon or activated charcoal are terms used for a porous carbon manufactured by a two step method
375 (carbonization followed by oxidation). The structure consists of a distorted three-dimensional array of aromatic sheets and
376 strips of primary hexagonal graphitic crystallites (Stoeckli, 1990). This structure creates angular pores between the sheets of
377 molecular dimensions that give rise to many of the useful absorption properties of activated carbon (Stoeckli, 1990, Innes
378 et. al., 1989). Pore size ranges from 1 nm to 1000 nm), and the extensive porosity is responsible for the high surface area
379 of the material (usually 500 - 1500 m²/gm.) (Vohler et. al., 1986, Cooney, 1980).

380
381 Carbon black or lamp black is another carbon product with high surface area. Lamp black consists of soot from burning a
382 carbon source (wood, tar, coal, oil, etc.) in a limited oxygen environment (Davidson et al., 1968). The high surface area and
383 surface properties of lamp black are derived from the fine particle size of the material, not from high porosity like
384 activated carbon. The lack of extensive porosity distinguishes activated carbon from other carbon products like lamp black
385 or charcoal. We will consider only true activated carbon in this review and its recommendations. Charcoal and lamp black
386 are distinct materials and should not be considered in an activated carbon TAP.

387
388 Charcoal was first used medicinally in 1550 B.C Egypt. and bone char has been in use since 1811 to decolorize sugar
389 (Cooney, 1980). True activated charcoal was not invented until the beginning of the last century and activated carbon
390 derived from coconuts was used in gas mask filters in the 1'st World War (Cooney, 1980).

391
392 Most any carbon material can be used to make activated carbon and the academic literature contains many references to
393 activated carbon derived from many agricultural and industrial high-carbon waste products. Commercial activated carbon,
394 however, is manufactured from only a few carbon sources; wood and sawdust, peat, coal, oil products, and nut shells and
395 pits (Vohler et. al., 1986, Davidson et al., 1968). Wood products and low-grade coal have some original porosity and are
396 easier to activate than dense materials such as anthracite (Vohler et. al., 1986; Sun et. al., 1997). However, any high carbon
397 material can be activated, and it is generally not possible to discern the original starting material of an activated carbon
398 product.

399
400 Activated carbon manufacturing consists of a charring or carbonization step in which most of the non-carbon material
401 (and much of the carbon) is volatilized by pyrolysis (usually between 500 and 750° C.). The weight loss is usually 60 to 70
402 % and much CO₂ is volatilized (Sun et. al., 1997, Diaz-Teran, 2001). Coal is usually first pre-oxidized at 150° to 250° C.
403 to prevent the coal from becoming thermoplastic during charring and collapsing the pore structure (Sun et. al., 1997).

404

405 The fine pore structure is formed in an activation process. In gas activation, an oxidizing gas such as CO₂ is used at high
406 temperature to erode pores into the char. In chemical activation, the char is impregnated with a chemical and then fired to
407 high temperatures (usually 800 to 1000° C). The activating chemical corrodes the carbon to form the pore structure.
408 Chemical activation also alters the carbon surface. Activation chemicals are usually strong acids, bases or corrosives
409 (phosphoric acid, sulfuric acid, KOH, zinc chloride, potassium sulfide, or potassium thiocyanate) (Mozammel et. al. 2002).
410 After activation, the chemicals are washed out for reuse. The final pore structure depends on the nature of the starting
411 material and the activation process (Diaz-Teran, 2001). Materials with an original pore structure like wood take less
412 processing than more dense and isotropic material like coal or tar. Impurity amounts are usually higher in the less carbon
413 dense materials, however.

414
415 The surface chemistry of the activated carbon is strongly influences by the activation process and subsequent chemical
416 treatment (Pradhan and Sandle, 1999). The surface contains abundant oxygen and hydrogen groups which can decompose
417 to CO₂ and water (Puri, 1966). Other surface oxide complexes that have been found include phenols, carbonyl, lactone,
418 carboxylic acid, and quinones (McCreey, 1991, Pradhan and Sandle, 1999). The abundance of surface complexes causes
419 activated carbon to be a good absorber of many gases and aqueous chemicals. The non-selective absorption of many
420 chemicals makes activated carbon an excellent absorber in poisoning or environmental contamination (Cooney, 1980).

421
422 Charcoal is generally considered to be a natural agricultural product. Both charcoal and carbon black form naturally (forest
423 fires), and have been used by man for thousands of years. Activated carbon does not occur naturally. A highly controlled
424 two- or three-stage process is needed to form the high porosity of activated carbon. The activation step also requires either
425 the addition of a synthetic chemical or direct injection of CO₂ or O₂ during the activation firing. Highly porous activated
426 carbon should considered synthetic. Bone char results from the destructive distillation of animal bones (Mantell, 1968;
427 Davidson et al., 1968). Bone char production does not include an activation step. It is more analogous to the left over
428 material in the destructive distillation of coal to make coal tar

429 *Interactions with Other Materials*

430
431 Any charcoal directly applied to a field would behave as any other organic source of carbon. Problems could arise from
432 the chemicals sequestered by the activated carbon when used on ill livestock, however. The purpose of activated carbon is
433 to absorb toxins accidentally ingested by livestock, allowing these toxins to safely pass through the GI track of the animal
434 without being absorbed by the body. These toxins would be then be deposited in the animal's manure. Animal manure
435 cannot contaminate crops, soil or water with pathogenic organisms, heavy metals or residues of prohibited substances (7
436 CFR 205.203(c). If the toxins can be broken down by composting without harming the composting organisms, the
437 contaminated manure can be composted (and documented in the organic management plan). If the toxins are heavy
438 metals, the manure must be disposed of without contaminating organic crop lands or water.

439 *Toxicity*

440
441 Activated carbon is generally considered non-toxic. Large doses are routinely given in human poisoning cases. The human
442 dose for poisoning is 1 gm activated charcoal per kg. body weight (Scharman et. al., 2001, Minocha et. al., 1985). Carthatics
443 such as sorbitol or Magnesium citrate are added to the activated carbon used for Poison cases. Magnesium citrate has
444 caused some fatalities and is rarely used (Benjamin, 1995). Human and animal studies report a small risk of aspiration
445 pneumonia when administering activated charcoal to intubated patients (~ 4%), (Moll et. al., 1999).

446
447 Activated charcoal has been shown to inherece in vitro growth of bile-tolerant *Helicobacter* bacteria (an emerging pathogen
448 of humans and animals) (Tanear, 2002). The mechanism appears to be the absorption of chemicals toxic to the bacteria.
449 Activated carbon has been reported to promote the growth of certain pathogenic bacteria (*Listeria monocytogenes*, and
450 *Legionella pneumophila*) (Erolaeva, 1999, Hoffman et. al., 1983). Potential mechanisms are absorption of toxins or reduction
451 of peroxide free radicals.

452 *Manufacture, Use, Misuse, and Disposal*

453
454 Activated carbon poses little risk of environmental contamination. The risk of manure of animals treated for poisoning is
455 discussed above. Many of the activation chemicals used to form the pore structure of activated carbon are toxic. Exposure
456 to Zinc Chloride fumes or solutions can cause ulceration and fatal burns Hamilton & Hardy, 1974). These chemicals are
457 reused and should be disposed of safely in large plants.

458
459 The carbonization step removes as much as 70 wt. % of the original carbon material as volatiles. 700,000 tons/yr of
460 activated carbon were manufactured in the late nineties (Mozammel et. al., 2002). This would release almost 500,000 tons
461 of volatiles (mostly Carbon Dioxide) to the atmosphere per year. The charring and activation processes also consume large
462 amounts of energy (Sun et. al., 1997).

463

464 Pharmaceutical grade activated carbon requires a low amount of non carbon components (Cooney, 1980). Carbon sources
465 like wood, peat or fruit shells generally have higher ash content than high-grade coal. USP grade activated carbon must
466 have < 15 wt % drying loss and < 3.5 % acid soluble residue (Cooney, 1980). Materials with a higher initial ash content
467 would need to be acid leached more than once with low initial ash content.
468

469 Almost any carbon source can be made into activated carbon (Vohler et. al., 1986). Without a detailed calculation, it is not
470 obvious which sources of carbon have a lower environmental footprint. Given this lack of knowledge of the
471 environmental costs of the different carbon sources, it would seem prudent to either allow or prohibit activated carbon
472 from any source in Organic management systems.
473

474 *Human Health*

475 As stated above, there is little danger from ingested activated carbon. Dust at manufacturing sites needs to be managed.
476 There is no unique hazard associated with activated carbon dust that is not encountered with other small particle sized
477 materials (activated charcoal is still used in respirator cartridges).
478

479 *Interactions with the Agroecosystem*

480 . . . [M]icrobiologists [*use activated carbon*] to help culture hard to grow pathogens *in vitro*. The effect of activated carbon on
481 rumen or gut bacteria flora is unknown. Occasional use of activated carbon in accidental poisonings appears to be a trivial
482 risk. Continuous use with tainted feed or poor pasture, however, presents an unknown risk, which may need to be studied.
483 The effect on the ecology of soil micro-organisms is also unknown, but the amount used to treat medical emergencies in
484 individual animals is too small to be of consequence.
485

486 *Alternatives*

487 Activated carbon absorbs and removes from the body a large range of toxic compounds (Cooney, 1980). It can be
488 administered at home or in the barn and is very effective when given within 30 min to 1 hour after poisoning (Grierson et.
489 al., 2001). Rival treatments include gastric lavage or emesis by mouth of syrup of ipecac or parenterally administered
490 apomorphine. Both can cause problems when used with certain poisons (including digitalis) (Cooney, 1980). Activated
491 carbon has also been shown to be as effective in poison cases as activated carbon + gastric lavage (Christophersen et. al.,
492 2002);
493

494 Many substances besides activated carbon are used to remove compounds in chemical and food processing (Adachi et. al.,
495 2000, Grohmann et. al., 1999). Zeolites, clays, and spent yeast cells have also been shown to absorb certain mycotoxins
496 from animal feed as well or better than activated carbon (Huwig et. al., 2001). The efficiency of these alternative absorbers
497 depends on the chemical structure of the toxin (Huwig et. al., 2001). These absorbers do not appear to be used in
498 emergency medicine (Cooney, 1980, Benjamin, 1995). Activated carbon—with its wide range of pore sizes and surface
499 complexes—is the universal antidote of choice.
500

501 *Compatibility with Sustainable Agriculture*

502 Organic livestock farmers must avoid many of the chemicals that could poison livestock. Accidental poisoning can occur,
503 however, when livestock ingests poisonous plants or mycotoxins on forage or haylage. Use of activated carbon to bind
504 these poisons is an expedient and safe emergency treatment. The main threat to the Organic system would come from the
505 poison present in the animal's manure, which can be easily managed in small quantities. Use of activated carbon in
506 emergency situations is compatible with organic production which promotes animal health and welfare.
507

508 Prophylactic use of activated carbon on a large group of animals to allow them to consume grain contaminated with toxins
509 or forage on pastures known to contain poisonous plants does not promote animal health and welfare. Activated carbon
510 absorbs much but not all of a toxin. Some of the toxins will not be removed from the body (Cooney, 1980). Animals
511 should be fed a nutritious ration, not a tainted ration with a poison remover added. Manure management becomes a larger
512 problem with prophylactic feeding of activated carbon mixed with toxic feed. Large amounts of toxin carrying manure
513 need to be composted or disposed of without contaminating the soil or water.
514

515 *Conclusion*

516 Activated Carbon with high porosity and surface area is a synthetic material. It is manufactured by a multistep process and
517 has no natural analog. Activated carbon also appears to be the most useful and safest antidote for accidental poisoning.
518 [*A farmer can*] quickly [*administer it*] after an animal is poisoned without a vet present. USP pharmaceutical grade has low
519 amounts of contaminants and is suitable for Organic operations.
520

521 Activated carbon from any raw carbon source is synthetic and should be added to the National List of Synthetic Livestock
522 Ingredients with the following annotations.

523 1. The activated carbon is USP pharmaceutical grade.

524 2. Activated carbon can only be used as livestock medication to treat accidental poisoning.
525 Prophylactic addition of activated carbon to feed contaminated with prohibited substances or natural toxins is prohibited.
526 Prophylactic treatment of livestock with activated carbon before turning out to forage in fields with toxic plants or known
527 toxins is also prohibited.
528
529
530

531 Reviewer #3 [*Analytical chemist and equestrian, West Coast*].
532

533 The literature available seems to be based on two subjects: therapeutic adsorption of ingested toxins and use of charcoal to
534 give animals a higher tolerance to plant toxins in their diet. I was unable to find any references to any other uses in
535 livestock management.
536

537 *Manufacture, Use, Misuse and Disposal*

538 Although the environmental impact of manufacturing charcoal from fossil-fuel derivatives is beyond the scope of this
539 report, the general rule is that fossil fuel based sources are undesirable within the realm of organic production. Unless
540 there is some specific reason to do otherwise (as in the use of summer oils, or plastic packaging in direct contact with
541 foods, for instance), it would be best to continue on with that precedent.
542

543 *Alternatives*

544 In terms of adsorbants for toxins, most other substances are either less effective, or have difficult side effects to deal with
545 (clays, for instance). And AC is often administered along with the other substances.
546

547 In terms of feeding AC to increase the intake of toxic or unpalatable plant materials, there **is** an alternative; the alternative
548 is to manage feeding in such a manner as to avoid the undesirable plants in the first place. I don't think there should be a
549 place in organic management for that practice.
550

551 Large applications of carbon to soil could unbalance the C:N ratio, however since carbon administration to animals should
552 be therapeutic, rather than routine, there should be little problem in managing the application.
553

554 It is also unlikely that concentrations of toxin in manure from AC treated animals would be high enough to cause
555 environmental problems, unlike AC used in waste and water treatment. When spent, it could, under some conditions have
556 adsorbed enough toxic material to pose disposal problems.
557

558 *Conclusion*

559 *a. the substance is **synthetic***; vegetable-based AC treated only with steam, CO₂, or N₂ could be considered non-synthetic
560 under current rule. However it is not clear that this class of AC can be adequately separated from all AC classes effectively
561 enough to require its exclusive use.
562

563 *b. for crops and livestock, the substance should be added to the national list as:*

564 ***synthetic, restricted***

565 It should not be allowed for all uses noted in the literature provided. The practice of feeding AC routinely to animals to
566 allow them to consume higher quantities of toxic or unpalatable plant material should be prohibited.
567

568 Therapeutic use to adsorb accidentally ingested toxins, including microbial toxin, mycotoxins, pesticides, and other toxins
569 should be allowed.
570
571
572

573 **The TAP Reviewers were also asked the following questions:**

574 General

575 *I. Sources and Manufacturing Processes*

576 Activated charcoal can be made from almost any carbonaceous material.

577 Are any sources non-synthetic or are they all synthetic?
578

579 *Reviewer 1*

580 Based on NOSB's clarification, sources of activated charcoal which are generated through a thermal activation process
581 should be classified as non-synthetic. Chemical activation should create a synthetic form of activated charcoal.
582

583 *Reviewer 2 covered this in the reviewer's comments.*

584

585 *Reviewer 3*

586 I think possibly that there could be sources of non-synthetic AC. However, as the market currently stands, I don't believe
587 that there is any way to differentiate between synthetic and non-synthetic.

588

589 *2. If some are non-synthetic, please indicate or specify criteria to determine what methods and processes make a 'natural' activated charcoal.*

590 *Note: while the NOP definition of synthetic includes anything chemically changed from a naturally occurring source, NOSB has historically*
591 *clarified this and followed the policy that heating and combustion of plants, animals and microorganism is not synthetic, while combustion of*
592 *minerals is synthetic. (1995- Definition and Interpretations).*

593 *Reviewer 1*

594 The synthetic form is impregnated with a chemical agent, whereas the non-synthetic form uses heating and combustion
595 only.

596

597 *3. Do you think charcoal could be considered an agricultural product?*

598 *a. If so, do you agree that it is feasible to produce activated charcoal that meets National Organic Program standards for being an organic*
599 *agricultural product?*

600 *b. Under what circumstances should non-organic activated charcoal be allowed?*

c:601 *If not, do you consider all sources non-agricultural?*

602

603 *Reviewer 1*

604 I consider all sources of activated charcoal at this time to be non-agricultural. However, if an agricultural product is raised
605 as certified organic, and the processing method is an approved form of processing, then the charcoal could be considered
606 an agricultural product.

607

608 I agree that it could be feasible to produce activated charcoal that meets National Organic Program standards. But it
609 would require some company or producer to take the risk of producing such a product.

610

611 Therefore, I think that non-organic activated charcoal should be allowed when there is a specific medical reason for using
612 it. I would recommend that the charcoal only be allowed from agricultural products, such as lumber, grain hulls, corn
613 cobs. The use of bones would fall under the voluntary ban on feeding of animal by-products.

614

615 *Reviewer 2 did not provide a separate answer.*

616

617 *Reviewer 3*

618 No. Some AC is made from wood; forestry is not considered an agricultural practice. The majority of AC is made from
619 agricultural and industrial byproducts, so there is no crop grown specifically for charcoal production.

620

621 *4. Is it correct to state that the FDA allows activated carbon from any source, provided that it meets food grade*
622 *(FCC) specifications (as a processing aid) or pharmaceutical (USP) specifications as an animal drug?*

623

624 *Reviewer 1*

625 It is correct to so state this.

626

627 *Reviewer 3*

628 Yes.

629

630 II. Action

631 *5. Is surface oxidation a redox reaction? Can you briefly explain the mechanism and give an example of how that*
632 *might work with the removal of a non-polar substance from solution?*

633

634 *Reviewer 1 declined to answer.*

635

636 *Reviewer 2*

637 AC absorbs by a variety of mechanisms. Surface complexes (see text) absorb by redox, steric, and ionic reactions (see Puri
638 1966; Pradhan, 1999; and Cooney, 1980). The microporosity also physically trap neutral molecules of specific sizes like
639 zeolites. [Multiple] mechanisms give AC such a wide range of adsorbants. They also make it less effective for any specific
640 compound. Ion exchange resins are better for ionic species and certain clays handle certain large organic molecules better.
641 The only specific structure AC seems to be the best on *is* phenolics.

642

643 *Reviewer 3 declined to answer*

644

645 For Livestock

646 6. What are the specifications for USP grade?

647 *Reviewer 1*

648 One gram of activated charcoal must adsorb 100 mg of strychnine sulfate in 50 ml of water.

649

650 *Reviewer 2*

651 USP activated charcoal should be fine, black, odorless, and tasteless powder which are free from gritty matter and which
652 possess the following additional characteristics: less than 15% weight loss on drying, < 4% residue after ignition, < 3.5%
653 acid-soluble substances, <0.2% alcohol-soluble substances, < 0.15% sulfate, < 0.02% chloride, and <0.005 % heavy metal
654 content.

655

656 *Reviewer 3*

657 loss on drying: <15%, Residue on ashing <4%, Acidity/alkalinity: aqueous filtrate is neutral to litmus paper, Sulfate:
658 aqueous filtrate = <1cc 0.02N H₂SO₄,chloride: <0.2%, acid-soluble substances: < 35mg in 1 g, heavy metals: <50ppm
659 total; adsorptive power: 1 g of AC will adsorb at least 100 mg strychnine

660

661 7. *Should vegetable-derived sources be allowed from non-organic sources, or should organic sources be required?*

662 *Reviewer 1*

663 Vegetable-derived sources should be allowed, if there are no organic sources available.

664

665 *Reviewer 2 did not provide a separate answer. See commentary.*

666

667 *Reviewer 3*

668 Vegetable-derived sources from non-organic sources should be allowed. The activation process removes almost all
669 impurities, except for some ash. Strictly organic source material would currently be impossible to fine. Also, current
670 manufacturers do not provide such a product.

671

6728. *Should animal-derived sources be allowed or should the ban on animal by-products be applied?*

673 *Reviewer 1*

674 I answered this above, but they should be banned.

675

676 *Reviewer 2 did not provide a separate answer.*

677

678 *Reviewer 3*

679 No. Any specific mention that I could find of medicinal uses of activated charcoal did specify “vegetable charcoal” .
680 USP, however, does not specify source material (“...residue of the destructive distillation of various organic materials,
681 treated to increase its adsorptive power...”).

682 9. *Should fossilized and mineral sources such as coal, petroleum, and other fossil-fuel derivatives (e.g. polymeric resins and waste tires) also be
683 allowed?*

684 *Reviewer 1*

685 I do not think that these sources should be allowed.

686

687 *Reviewer 2 did not provide a separate answer.*

688

689 *Reviewer 3*

690 Manufacture of AC from fossil-fuel derivatives poses significantly more environmental problems than that of agriculture-
691 based AC. In general, fossil-fuel derivatives are prohibited, except under very specific circumstances. I see little reason to
692 stretch that stricture to include these products.

693 10. Would use to facilitate grazing of toxic plants be considered a feed supplement or health care?

694 *Reviewer 1*

695 It should be considered a feed supplement.

696

697 *Reviewer 2*

698 [*Purposefully*] feeding animals AC before turning out to toxic pasture is . . . added as an annotation.

699

700 *Reviewer 3*

701 I would consider it a feed supplement.

702

703 11. *What are the environmental consequences of using activated carbon to facilitate grazing toxic plants?*

704 *Reviewer 1*

705 In my opinion, the main issue here is not environmental consequences, but the ethical and animal welfare questions of
706 attempting to change the toxicity of plants in a way that will make them safe(r) for livestock. There are natural methods of
707 introducing certain plants for certain species and classes of livestock. But avoidance is one of the instinctive ways livestock
708 protect themselves from harmful substances. Altering this natural behaviour with a feed supplement does not conform to
709 the principles behind organic agriculture.

710

711 *Reviewer 2 did not provide a separate answer.*

712

713 *Reviewer 3*

714 One could argue that this produces nothing but good; an easy way to remove undesirable plants from overgrazed and
715 mishandled land, and a good way to get cheap feed into livestock.

716 However, this practice flies in the face of all good organic practice. It allows the deliberate and systematic feeding of
717 poor-quality forage, which certainly does not support the philosophy of caring for animals in the best possible way.

718 Environmentally, it allows for continued exploitative pasture management practices, and removes one strong motivation
719 for proper pasture management. Ground should be managed in such a way that toxic and undesirable vegetation is
720 discouraged.

721 The feeding of AC should be therapeutic; not preventative. To allow animals to graze on pasture so poor that they must
722 eat toxic plants should be discouraged on all levels. AC should be used to remedy the accidental ingestion of mycotoxins,
723 pesticides, etc., not to cover for poor management practices.

724 I don't think feed-through would pose a major problem; toxic levels of these chemicals are relatively low, in most cases.

725 The chemical would bind tightly to the charcoal, and when excreted would gradually break down and be deposited in the
726 soil. I am finding it difficult to picture a situation where animals with a large enough drug or toxin load would be in a
727 situation to produce enough loaded excrement to engender an environmental threat. Unlike waste and water treatment, it
728 is not likely that there would be large amounts of spent AC to deal with.

729

73012. *Should the use of activated carbon to conceal the use of substances prohibited in organic farming—such such as synthetic pesticides and drugs—
731 be a concern of the NOSB?*

732 *Reviewer 1*

733 They should not be a concern for several reasons. Certifiers are going to the people responsible for seeing that producers
734 comply with standards. Since pesticides and drugs go through a metabolism process within an animal, treating with
735 charcoal to conceal their use would be unlikely to be of benefit. Finally, if people are going to go to such extreme
736 measures to hide use of prohibited substances, they are going to succeed, no matter what measures are put in place.

737

738 *Reviewer 3*

739 Yes, this could certainly be a possibility, although I don't have any specific knowledge of such a situation.

740

741

742 **Conclusion:**

743 Activated charcoal is essential to save the lives of animals that are accidentally poisoned. The reviewers all advised that the
744 substance should be permitted for use in organic production, provided it was limited to therapeutic use only. Given the
745 nature of the veterinary emergencies likely to be encountered, restrictions on source do not appear to be appropriate. Most
746 pharmaceutical grade activated charcoal is derived from vegetable—as opposed to animal or fossil—sources. Overall
747 restrictions on its prophylactic use as a feed supplement and to conceal the administration of substances prohibited in
748 organic production would protect against possible abuse.

749

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