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Authors: Provides an updated overview on efficacy of biocidal active substances and antiseptics Explores the potential of those agents to enhance tolerance and cross-resistance of bacteria to antibiotics Helps reduce unnecessary selection pressure and maintain the efficacy of useful antiseptics 8131 Accesses 3 Citations This updated and expanded second edition of Antiseptic Stewardship serves as a comprehensive reference guide to common biocidal active substances and antiseptic agents, examining their antimicrobial efficacy and potential to induce cell tolerance, including cross-tolerance to other biocidal agents, as well as cross-resistance to antibiotics. In addition, the book discusses the appropriate and targeted use of biocidal active substances by balancing their expected health benefits against the likelihood of clinically relevant resistance, including misuse and overuse of some products during the COVID-19 pandemic. This guide, which focuses on human, veterinary and household products, helps readers make informed decisions about disinfectants and antiseptic products based on their composition. Various biocidal active substances and antiseptic agents are used for disinfection and antisepsis in healthcare, veterinary medicine, animal production and household products. However, not all of them provide significant health benefits, especially for some products used in human medicine. Antimicrobial soaps, surface disinfectants, instrument disinfectants and wound antiseptics may contain one or more biocidal active ingredients with comparable antimicrobial efficacy, but with large differences in their potential for microbial adaptation and tolerance. Increased bacterial tolerance has been described for several biocidal active substances and antiseptics, sometimes including cross-resistance to antibiotics. The book is therefore intended to help reduce unnecessary selection pressure on emerging pathogens, including by describing non-biocidal alternatives for specific antimicrobial applications, with the aim of retaining the powerful biocidal agents and antiseptics for those applications where there is a clear health benefit (e.g. reduction of healthcare-associated infections). The book addresses healthcare, industrial and veterinary professionals as well as educated laypersons interested in efficient and controlled disinfection strategies. Günter Kampf is an Associated Professor for Hygiene and Environmental Medicine at the University of Greifswald, Germany. He has published more than 250 mostly international articles on various aspects of infection control, such as hand hygiene, surface disinfection and the epidemiology of COVID-19. He has published so far 11 textbooks on hand hygiene, surface hygiene and the epidemiology of COVID-19. As a recognized medical specialist in hygiene and environmental medicine, he worked for a manufacturer of chemical disinfectants for 18 years, the last 5 years of which as Director of Science. Since 2016 he has been self-employed and continues his scientific work together with infection control consultancy for hospitals, medical practices and companies with infection control issues. InChI=1S/C22H48N.ClH/c1-5-7-9-11-13-15-17-19-21-23(3,4)22-20-18-16-14-12-10-8-6-2;/h5-22H2,1-4H3;1H/q+1;/p-1InChIKeyInChIKey=RUPBZQFQVRMKDG-UHFFFAOYSA-MSMILESC([N+](CCCCCCCCCC)(C)C)CCCCCCCCC.[Cl-]Canonical SMILES[Cl-].CCCCCCCCCC[N+](C)(C)CCCCCCCCCCOther Names for this Substance1-Decanaminium, N-decyl-N,N-dimethyl-, chloride (1:1)Ammonium, didecyldimethyl-, chlorideDidecyldimethylammonium chloride1-Decanaminium, N-decyl-N,N-dimethyl-, chlorideDimethyldidecylammonium chlorideDeleted or Replaced CAS Registry Numbers126851-24-9, 129186-13-6, 154765-32-9, 446279-85-2, 879292-51-0, 1094740-76-7, 1632379-58-8 Cosmetics and personal care products are not required to be tested for safety before being allowed on the market. The Skin Deep® scoring system was designed to help the public understand whether a product is safe to use or whether it contains ingredients of concern. Every product and ingredient in Skin Deep gets a two-part score – one for hazard and one for data availability. The safest products score well by both measures, with a low hazard rating and a fair or better data availability rating. HOW WE DETERMINE SCORES The Skin Deep ingredient hazard score, from 1 to 10, reflects known and suspected hazards linked to the ingredients. The EWG Verified® mark means a product meets EWG's strictest criteria for transparency and health. The Skin Deep data availability rating reflects the number of scientific studies about the product or ingredient in the published scientific literature. NONE LIMITED FAIR GOOD ROBUST Didecyldimethylammonium chloride Names Preferred IUPAC name N-Decyl-N,N-dimethyldecan-1-aminium chloride Other names DDAC Dimethyldidecylammonium chloride[1][2] 1-Decanaminium[1] N-decyl-N,N-dimethyl-, chloride[1] Didecyldimethylammonium chloride[1] Didecyl dimethyl ammonium chloride[1] Quaternium-12[1] Ammonium, didecyldimethyl-, chloride[1] Identifiers CAS Number 7173-51-5 Y 3D model (JSmol) Interactive image ChEMBL ChEMBL224987 Y ChemSpider 22027 Y ECHA InfoCard 100.027.751 PubChem CID 23558 UNII JXN40O9Y9B Y CompTox Dashboard (EPA) DTXSID9032537 InChI InChI=1S/C22H48N.ClH/c1-5-7-9-11-13-15-17-19-21-23(3,4)22-20-18-16-14-12-10-8-6-2;/h5-22H2,1-4H3;1H/q+1;/p-1 YKey: RUPBZQFQVRMKDG-UHFFFAOYSA-M YInChI=1/C22H48N.ClH/c1-5-7-9-11-13-15-17-19-21-23(3,4)22-20-18-16-14-12-10-8-6-2;/h5-22H2,1-4H3;1H/q+1;/p-1Key: RUPBZQFQVRMKDG-REWHXWOFAJ SMILES [Cl-].C(CCCCC[N+](C)(C)CCCCCCCCCC)CCCC Properties Chemical formula C22H48ClN Molar mass 362.08 g/mol Appearance liquid[3] Density 0.87 g/cm3 (20 °C)[3] Pharmacology ATC code D08AJ06 (WHO) Hazards Occupational safety and health (OHS/OSH): Main hazards corrosive[3] GHS labelling: Pictograms Except where otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa). Y verify (what is YN ?) Infobox references Chemical compound Didecyldimethylammonium chloride (DDAC) is a quaternary ammonium compound used as an antiseptic/disinfectant. It causes the disruption of intermolecular interactions and the dissociation of lipid bilayers. The bacteriostatic (prevent growth) or bactericidal (kill microorganism) activity of DDAC depends on its concentration and the growth phase of the microbial population.[4] It is a broad spectrum biocidal against bacteria and fungi and can be used as disinfectant cleaner for linen, recommended for use in hospitals, hotels and industries. It is also used in gynaecology, surgery, ophthalmology, pediatrics, OT, and for the sterilization of surgical instruments, endoscopes and surface disinfection. In mice this disinfectant was found to cause infertility and birth defects when combined with alkyl (60% C14, 25% C12, 15% C16) dimethyl benzyl ammonium chloride (ADBAC).[5][6] These studies contradict the older toxicology data set on quaternary ammonia compounds which was reviewed by the U.S. Environmental Protection Agency (U.S. EPA) and the EU Commission.[7] In addition, DDAC, as well as other quaternary ammonia compounds, can lead to the acquisition of resistance by microorganisms when employed in sub-lethal concentrations.[8] Dimethyldioctadecylammonium chloride – longer di-C18 analogue ^ a b c d e f g "Didecyl dimethyl ammonium chloride", Household Products Database, US Department of Health and Human Services, 2016 ^ "didecyl(dimethyl)azanium;dimethyl(dioctyl)azanium;dichloride". PubChem. National Center for Biotechnology Information. 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ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Please enable Javascript in order to use PubChem website. Stereochemistry ACHIRAL Molecular Formula C22H48N.Cl Molecular Weight 362.076 Optical Activity NONE Defined Stereocenters 0 / 1 E/Z Centers 0 Charge 0 SHOW SMILES / InChI [Cl-].CCCCCCCCCC[N+](C)(C)CCCCCCCCCC InChIKey=RUPBZQFQVRMKDG-UHFFFAOYSA-M InChI=1S/C22H48N.ClH/c1-5-7-9-11-13-15-17-19-21-23(3,4)22-20-18-16-14-12-10-8-6-2;/h5-22H2,1-4H3;1H/q+1;/p-1 HIDE SMILES / InChI DIDECYLDIMONIUM (as a salt, didecyldimethylammonium chloride (DDAC)) is used in many types of biocidal products including tableware, carpets, humidifiers, and swimming pools. It shows a broad spectrum of activity against both gram-positive and gram-negative bacteria and is also effective on fungi and viruses, including those that are enveloped. Name Type Language Preferred Name English Official Name English Systematic Name English Common Name English Systematic Name English Common Name English Common Name English Common Name English Common Name English Common Name English Systematic Name English Common Name English Systematic Name English Common Name English Common Name English Classification Tree Code System Code WHO-ATC D08AJ06 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 EPA PESTICIDE CODE 69149 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 WHO-VATC QD08AJ06 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 Code System Code Type Description C027118 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY 1011450 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY RxNorm 230-525-2 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY JXN40O9Y9B Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY 7611 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY SUB73378 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY Didecyldimethylammonium chloride Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY 100000136088 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY 4416 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY 7173-51-5 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY JXN40O9Y9B Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY DTXSID9032537 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY DBSALT002532 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY 23558 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY m4380 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY Merck Index CHEMBL1182247 Created by admin on Mon Mar 31 18:46:03 GMT 2025 , Edited by admin on Mon Mar 31 18:46:03 GMT 2025 PRIMARY Please enable Javascript in order to use PubChem website. About, Contact Us, Copyright, Privacy, AccessibilityU.S. Food and Drug Administration, 10903 New Hampshire Ave, Silver Spring, MD 20993-0002U.S. Food and Drug Administration, Health & Human ServicesFreedom of Information ActPowered by As a library, NLM provides access to scientific literature. Inclusion in an NLM database does not imply endorsement of, or agreement with, the contents by NLM or the National Institutes of Health. Learn more: PMC Disclaimer | PMC Copyright Notice . Author manuscript; available in PMC: 2016 Jul 26. Didecyldimethylammonium chloride (DDAC) is a dialkyl-quaternary ammonium compound that is used in numerous products for its bactericidal, virucidal and fungicidal properties. There have been clinical reports of immediate and delayed hypersensitivity reactions in exposed individuals; however, the sensitization potential of DDAC has not been thoroughly investigated. The purpose of these studies was to evaluate the irritancy and sensitization potential of DDAC following dermal exposure in a murine model. DDAC induced significant irritancy (0.5 and 1%), evaluated by ear swelling in female Balb/c mice. Initial evaluation of the sensitization potential was conducted using the local lymph node assay (LLNA) at concentrations ranging from 0.0625–1%. A concentration-dependent increase in lymphocyte proliferation was observed with a calculated EC3 value of 0.17%. Dermal exposure to DDAC did not induce increased production of IgE as evaluated by phenotypic analysis of draining lymph node B-cells (IgE+B220+) and measurement of total serum IgE levels. Additional phenotypic analyses revealed significant and dose-responsive increases in the absolute number of B-cells, CD4+ T-cells, CD8+ T-cells and dendritic cells in the draining lymph nodes, along with significant increases in the percentage of B-cells (0.25% and 1% DDAC) at Day 10 following 4 days of dermal exposure. There was also a significant and dose-responsive increase in the number of activated CD44 + CD4 + and CD8+ T-cells and CD86+ B-cells and dendritic cells following exposure to all concentrations of DDAC. These results demonstrate the potential for development of irritation and hypersensitivity responses to DDAC following dermal exposure and raise concerns about the use of this chemical and other quaternary ammonium compounds that may elicit similar effects. Keywords: DDAC, hypersensitivity, allergic disease, quaternary ammonium compound Quaternary ammonium compounds (QAC) are commonly used as water-based surface disinfectants due to their low volatility and they are increasingly being used in hospitals, hotels and in consumer products (Zhang et al. 2015) due to their broad antimicrobial capabilities. In healthcare settings they are frequently used in clinical settings for the decontamination of surgical instruments, endoscopes and other medical instruments. The use of QAC as antiseptics, disinfectants, detergents and preservatives has increased their incorporation into consumer products that are utilized orally (mouthwash) or applied to the skin or eyes for the purpose of decreasing microbial contamination and reducing the incidence of pathogen-induced illness. All QAC are permanently charged ions with four alkyl side chains. Their structures contain at least one hydrophobic hydrocarbon chain linked to a positively charged nitrogen atom and other alkyl groups that are mostly short-chain substitutes such as methyl or benzyl groups. The biocidal activity is conferred through alkyl chain length (McBain et al. 2004). The ability to adapt and optimize QAC structure to target specific microbial species has recently increased the utilization of these compounds for use in consumer products (Carson et al. 2008). Dialkyl QAC represent the newest generation of QAC and exhibit a wide spectrum of activity. These new synthetic polymeric QAC contain multiple positively-charged amine centers that confer anti-microbial, antistatic, and surfactant properties in solution. One of the newer QAC in common use is didecyldimethylammonium chloride (DDAC). DDAC is a broad-spectrum bactericidal and fungicidal biocide that exhibits antimicrobial activity against several pathogens such as Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa (Walsh et al. 2003), Legionella pneumophilia (Skaliy et al. 1980), Stachybotrys chartarum and enveloped and non-enveloped viruses (Argy et al. 1999). It is used in several types of applications including: industrial processes, swimming pools and aquatic areas, wood treatment, healthcare and food handling and storage (Ohnuma et al. 2011). QAC have been used for over 50 years and have generally been regarded as safe; however, there is very limited published research describing the toxicity of these compounds, especially regarding the newer formulations such as DDAC. A study conducted by Ohnuma et al. (2011) examined the pulmonary defense system following a single intratracheal instillation of DDAC (60 and 150 μg/kg) in C57BL/6J mice. Those authors found that exposure to the high dose induced lung injury as early as 1-d post-exposure, as evidenced by increased lactate dehydrogenase (LDH) activity and protein concentrations in the bronchoalveolar (BAL) fluid. There was also an increase in total cells in the BAL (specifically macrophages, neutrophils and lymphocytes), along with increases in interleukin (IL)-6 production by 7-days post-exposure. The authors also suggested that DDAC exposure altered oxidative stress and antimicrobial markers (evaluated by gene expression) in the lungs and systemic co-exposure with lipopolysaccharide (LPS) generated a further enhancement in pulmonary inflammation suggesting a potential increase in susceptibility to bacterial agents. A more recent study investigated the effects of DDAC following a 2-week inhalation exposure (Lim & Chung 2014) in Sprague-Dawley rats. Aside from decreases in body weight at the highest exposure concentration (3.6 mg/m3), no changes in hematological and blood biochemistry parameters were observed and mild changes were observed in BAL cell counts and cell damage parameters. Interestingly, a recent study observed that, following the introduction of DDAC in an animal facility there was decreased reproductive performance of the laboratory mice. Additional examination identified decreases in fertility and fecundity including increased time to first litter, longer pregnancy intervals, fewer pups per litter and fewer pregnancies in mice following DDAC exposure (Melin et al. 2014). Epidemiological data and case studies indicate that healthcare workers have an elevated risk for development of sensitization and allergic asthma from either dermal or inhalation exposure to chemicals compared to non-healthcare workers (Warshaw et al. 2008). Biocides such as QAC have been identified to be among the most common allergens in the healthcare profession (Bernstein et al. 1994; Purohit et al. 2000; Shaffer & Belsito 2000; Suneja & Belsito 2008; Gonzalez et al. 2014). A study evaluating 142 patients with suspected allergies to the most commonly used QAC, i.e. benzalkonium chloride (BAC) and benzethonium chloride (BEC), confirmed sensitization by patch test to these compounds in 20% of the patients and identified potential co-reactions between the two QAC in 85% of the subjects who tested positive (Dao et al. 2012). While there have been fewer overall reported cases of sensitization to the newer formulations of QAC, allergic contact dermatitis and immediate-type allergic reactions caused by DDAC exposure have been recently reported. Four cases, which were confirmed by patch testing or open epicutaneous tests, describe contact dermatitis presenting in hospital and laboratory workers on the hands/wrists and face following exposure to DDAC present in a disinfectant (Dejobert et al. 1997; Dibo & Brasch 2001; Ruiz Oropeza et al. 2011). In addition, there is also a confirmed case of allergic contact dermatitis of the foot resulting from exposure to DDAC that was present in a shoe refresher spray (Mowitz & Ponten 2015). There has also been one case of immediate allergy reported in an individual in catering school who was exposed to DDAC in a cleaning product. This individual suffered from urticaria, facial angioedema and dyspnea within 10 min of exposure. A 20-min open epicutaneous test with the diluted cleaning product and DDAC confirmed immediate-type hypersensitivity (Houtappel et al. 2008). All symptoms in the individuals resolved when exposure to DDAC was eliminated. While these studies suggest a role for QACs and DDAC in allergic disease, the exact mechanism of action for sensitization to these compounds remains to be investigated and explained. Due to the high potential for human exposure, epidemiological studies suggesting an association with allergic disease and the lack of dermal toxicological data, this study was performed to evaluate the irritancy and skin sensitization potential of DDAC using a murine model in an effort to assess its role in the development of allergic disease. Female BALB/c mice were used for the murine models. This mouse strain has a T-helper (TH)-2 bias and is commonly used to evaluate IgE-mediated sensitization (Woolhiser et al. 2000; Klink & Meade 2003). The mice were purchased from Taconic (Germantown, NY) at 6–8 weeks-of-age. Upon arrival, the animals were allowed to acclimate for a minimum of 5 days. Each shipment of animals was randomly assigned to a treatment group, weighed and individually identified (via tail marking) using a permanent marker or tattoo. A preliminary analysis of variance on body weights was performed to ensure a homogeneous distribution of animals across treatment groups. The animals were housed at a maximum of 5/cage in ventilated plastic shoebox cages with hardwood chip bedding. NIH-31 modified 6% irradiated rodent diet (Harlan Teklad) and tap water were provided from water bottles, ad libitum. The animal facility temperature was maintained at 68–72°F and the relative humidity between 36–57%. A light/dark cycle was maintained on 12-h intervals. All animal experiments were performed in the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) accredited NIOSH animal facility in accordance with an animal protocol approved by the Institutional Animal Care and Use Committee. Dimethyldidecylammonium chloride (DDAC; CAS#7173-51-5; Figure 1), acetone (CAS#67-64-1), α-Hexylcinnamaldehyde (HCA; CAS#101-86-0) and 2,4-toluene diisocyanate (TDI; CAS#584-84-9) were purchased from Sigma-Aldrich (Milwaukee, WI). Chemical structure of DDAC. Concentration range finding studies were performed to select the concentrations of DDAC to be used for dermal exposures. Mice (n = 3/group) were exposed topically to acetone vehicle or increasing concentrations of DDAC (up to 40%) in acetone on the dorsal surface of each ear (25 μl per ear) for three consecutive days. Acetone was selected as the appropriate vehicle based on solubility, historical control data and accepted use in skin sensitization studies (NIEHS 1999). Animals were allowed to rest for 2 days following the final exposure and then weighed and examined for signs of overt toxicity including loss of body weight, fatigue/lack of activity and ungroomed fur. To determine the irritancy and sensitization potential of DDAC, a combined LLNA was conducted as previously described (Anderson et al. 2007) and according to the method