

Chemistry of nicotine

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CHEMISTRY OF NICOTINE Date Submitted: March 17, 2010 Introduction

Tobacco has a long history and has had a significant impact since first introduced to Western society in the 16th century. There is evidence that Native Americans were using tobacco long before the 16th century. They smoked through a pipe for special religious and medical purposes but the worldwide spread of tobacco was initiated as a result of European discovery by Spanish, Portuguese and French explorers.(1, 2) Christopher Columbus testified to the widescale use of tobacco by Native Americans but Jacques Cartier stands as the first known explorer to experiment with tobacco.(2) By the time the Europeans settled in North America, tobacco had become the most important crop providing colonies with a primary export and source of income.(3) Approximately 0.6-3.0% of dry weight of tobacco consists of the alkaloid, Nicotine, originating from the Solanaceae family of plants.(4, 5) It is found in the tobacco leaves as biosynthesis takes place in the roots. The name Nicotine is derived from the tobacco plant, *Nicotiana tabacum*, which was named after Jean Nicot, a French ambassador who sent tobacco seeds from Portugal to Paris in 1550 and promoted its medicinal use.(4, 6) In 1828 two German chemists Posselt and Reinmann were the first to isolate Nicotine from the tobacco plant and considered it as a poison. In 1843, Melsens described its chemical empirical formula and the first synthesis was done in 1904 by A. Pictet and Crepieux.(4) As colonialism spread all over the world and as tobacco farming became more and more profitable, the image of smoking began to change. By the mid 1800's, cigarette smoking became socially acceptable but truly increased in the 1880's when James Bonsack invented the cigarette-making machine with the ability to produce 120,000

cigarettes a day.(3) As one can imagine, this caused tremendous growth in the tobacco industry open until the 20th century where health consequences due to smoking became public knowledge.(1) Addictive Properties of Nicotine There are many definitions for what is considered to be addicting but although these definitions are not identical, they have several criteria in common for establishing a drug as addictive. The central element in all forms of drug addiction is that the user's behavior is largely controlled by a psychoactive substance.(7) Nicotine is proven to be the psychoactive substance in tobacco. Nicotine has different mood-altering effects and is considered to be both a stimulant and a relaxant. User reports show feelings of calmness, relaxation, sharpness and alertness. In some cases smokers may lose weight by reducing their appetites and raising metabolism. All of these outcomes are directly related to nicotine's effect on the brain.(7) When a cigarette is smoked, nicotine travels through the bloodstream from the lungs to the brain and stimulates the release of many neurotransmitters that are largely responsible for most of nicotine's effects.(7) The more important being acetylcholine and dopamine. Enhanced concentration, memory, alertness as well as a reduction of pain are all due to an increase in acetylcholine.(8) Nicotine also extends the duration of positive effects of dopamine and increases sensitivity in brain reward systems.(7, 8) Dopamine is one of the more important neurotransmitters actively involved in the brain and with increasing levels, research shows that nicotine acts as a chemical with intense addictive qualities.(7) Nicotine's addictive effect relates to its ability to trigger the release of dopamine in the brain which is associated with the feelings of pleasure.(7) More simply, the use of nicotine causes

changes in the brain that make people want to use more and more of the drug. Nicotine in the Cigarette Smoke Depending on the brand, cigarettes contain 8 to 20 milligrams of nicotine but generally your body absorbs only about 1 mg when you smoke a cigarette.(7) The type of tobacco, whether the smoke is inhaled, and whether a filter is used are some of the many factors that affects the amount of nicotine absorbed by the body from smoking.(4) Nicotine is a water and lipid soluble drug that is readily absorbed through respiratory tissues, skin and the gastrointestinal tract.(9) The absorption of nicotine through cellular membranes depends on the pH level. The acidity of tobacco smoke allows little absorption in the mouth and therefore inhalation is needed to allow nicotine to be absorbed by the huge area of alveoli and small airways.(7, 9) The nicotine is absorbed quickly through the lungs due to the large surface area of the alveoli and the dissolution of nicotine at the physiologic pH of 7.4, where nicotine passes through the membranes easily.(10) When nicotine enters the body, it is circulated quickly through the bloodstream, is distributed rapidly among all the organs and takes about seven seconds on average for the substance to reach the brain.(11) Therefore, about 10 to 15 seconds after inhaling, many smokers begin to feel the effects of nicotine. Everybody metabolizes nicotine at different rates depending on how effective the enzymes in their livers break down nicotine. About 80 percent of nicotine is broken down to the major metabolite cotinine by cytochrome P450 enzymes in your liver.(4) It is also metabolized in your lungs to nicotine oxide and cotinine. Nicotine doesn't stay in your body for long, it has a half-life of approximately 60 minutes.(11) Cotinine as well as the other metabolites are excreted in your

urine. You can test whether or not someone has been smoking in the past few days by screening the urine for cotinine since it has a 24-hour half-life.

(11) The remaining nicotine is also excreted in the urine after being filtered from the blood by your kidneys.(11) Adverse Health Effects of Smoking There are many short-term and long-term effects of smoking. Immediately after smoking some changes in the body can be monitored. A person's blood pressure and heart rate are increased, blood flow to hands and feet are reduced and there is active stimulation to the brain and nervous system.(7, 11) Smoking also impairs your ability to concentrate by decreasing the amount of oxygen that goes to your brain. Other less serious short-term effects are stained teeth and fingers, bad breath, coughing, a reduced immune system with longer recovery times, and reduced potency in men and fertility in women.(7) When it comes to long-term smoking effects, it is generally the body's respiratory system that suffers the most. The two major infections that result are pneumonia and chronic bronchitis.(9, 12) Cigarette smoking accounts for a third of all heart disease deaths.(12) Coronary disease is common leading to heart attacks due to vascular disease and the heart over working. The amount of cholesterol clogging the arteries is increased due the carbon monoxide in the smoking as well as the stiffness in the walls of the arteries increasing the risk of rupture.(7) Lung, throat, mouth, stomach, bladder are just some of the many kinds of cancers that are related to smoking.(12) In fact, smoking is involved in most of all lung cancer deaths. The effects of smoking are arguably even worse in nonsmokers as in smokers. Second hand smoking results in about 53, 000 deaths a year in the United States and about 37, 000 of these deaths are related to

cardiovascular disease.(7) Tobacco smoke is made up of many hazardous particles that are also harmful to the others around the smoker. The smoke at the end of a burning cigarette has smaller and more harmful particles than the smoke inhaled by the smoker and these smaller particles go deeper into the lung tissue causing more damage.(9) Smoking also has harmful effects particularly on women. Lung cancer caused by smoking is now responsible for the most female deaths among all cancers. Women over 35 who smoke and are in a higher risk group for heart attack, stroke and blood clots of the legs.(7) Pregnant women who smoke expose their children to sudden infant death syndrome, increase chances of stillbirth, low birth weight of the baby, respiratory Infections, colic, placenta abruption, premature birth and miscarriage.(13) Teens start to experiment with smoking at younger ages, resulting in emotional and physical effects. Teens that smoke are usually subject to more absenteeism at school due to respiratory infections leading to lower grades and have a tendency to continue smoking throughout their lives.(7) Children have tender tissues and are more sensitive to second hand smoke which is partly the reason why they may develop cancers when they get older. Children that are raised in a home with parents that smoke are shown to have more colds, ear infections, bronchitis, and other respiratory problems compared to children of smoke-free families.(7) Smoking Cessation Products Nicotine replacement therapy (NRT) helps reduce nicotine withdrawal and craving by supplying your body with nicotine.(14) Nicotine replacement therapy is only useful for people who are trying to quit and should be avoided if you are pregnant or have a heart disease.(15) It has been proven that the use of any form of nicotine

replacement therapy equally doubles your chances of quitting smoking.(16)

There are many available products aimed to help people permanently beat their nicotine addiction. The prescription and over-the-counter products that contain nicotine vary from the more common nicotine gum, lozenges, nicotine patches and inhalers to the less common, nicotine nasal spray.

Nicotine gum is a type of chewing gum that provides nicotine to the bloodstream after being absorbed by the tissues of the mouth.(17) The gum is available over-the-counter and has a nicotine content of about 1 or 2 cigarettes. The side effects of nicotine gum use may include bad taste from the gum, hiccups, nausea or heartburn, jaw pain, hair loss and possibly birth defects if consumed during pregnancy.(17, 18) Lozenges are over-the-counter tablets that release nicotine slowly in the mouth when sucked and usually take 20-30 minutes to fully dissolve.(17) Just like the gum, the nicotine is absorbed through the lining of the mouth and enters the bloodstream. The side effects are also similar to those of nicotine gum. They may include upset stomach, hiccups, heartburn, headache and excessive gas.(17) Nicotine patches are available over the counter. They stick to your skin and slowly release nicotine through your skin and into your bloodstream.(17) The nicotine patch costs about 20-30\$ per week although in some places they offer subsidized patches to encourage smoking cessation.(19) Common side effects include dizziness, headache, sleep disturbances, vivid dreams, mild hallucinations, depression and skin irritation.(17, 19) The nicotine inhaler is only available with a doctor's prescription. It has a holder that contains nicotine and it provides a puff of nicotine vapor into your mouth and throat. It acts as a replacement for

people who miss the 'hand to mouth' aspect of smoking.(17) Possible side effects for the nicotine inhaler are a scratchy throat, a cough, and an upset stomach. This product should be avoided if you have asthma, allergies or a sinus condition.(17) The nicotine nasal spray is not widely used and just like the inhaler, it is only available with a doctor's prescription. It provides a quick and effective dose of nicotine through the lining of your nose. The common side effects for this product are nasal irritation, diarrhea and a fast heart rate.(17) Although there is a wide range of nicotine replacement products for smoking cessation, there are also available products that do not contain nicotine such as Chantix and Zyban. Chantix and Zyban are both prescription medicine used to help people stop smoking and both are not available to pregnant women. Chantix, marketed by Pfizer, is effective because it binds to nicotine receptors in the brain reducing both your cravings for a cigarette and decreases the pleasurable effects when you do smoke.(17) Basically, you begin to take tablets a few weeks before you want to stop smoking and treatment usually lasts for 12 weeks. The more common side effects include nausea, insomnia, headaches, abnormal dreams, gas, changes in taste, constipation, and depression.(20) Zyban, manufactured by GlaxoSmithKline, is a treatment that alters the way that your body responds to nicotine. It helps block the reuptake of norepinephrine and dopamine so that more of each chemical remains in the space between the brain's nerve cells which is thought to help people be more successful at smoking cessation.(17) Just like Chantix, you begin to take Zyban tablets a few weeks before you quit and treatment usually lasts for a couple of months to help you through the withdrawal cravings. The common side effects include insomnia, a runny

nose, dry mouth, dizziness, nausea, trouble concentrating, constipation, joint pain, unusual dreams, muscle pain, diarrhea and nervousness.(21)

Conclusion After researching the addictive properties in nicotine, nicotine in the body, the short-term and long-term effects and the range of smoking cessation products available, it is evident that there are no positive effects of smoking and a lot of time and effort is needed to break the addiction to nicotine. Fortunately, smoking is becoming less socially acceptable consistently throughout the world. The majority of workplaces have some types of restrictions, and there are even employers looking to hire preferable non-smokers. Public buildings, concerts, even sporting events are largely smoke-free. Smokers are subject to more and more limitations in their everyday lives and hopefully one day, this will lead to a completely smoke-free public environment. The most important task at hand is that public knowledge and awareness is increasingly encouraged in order to make the world a better place for everyone.

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