

Chapter 7

Anti-Alopecia Materials/Anti-Dandruff Agents

Perry Romanowski

1. Introduction

The primary goal of most hair formulations is hair cosmetic improvement. One of the main ways this is achieved is with cleansing products, such as shampoos that remove dirt and oil from hair. Conditioning products are also used to improve the look and feel of hair. Finally, styling products are used to help make hair more manageable and stay in the shape desired by consumers.

But some hair formulations are designed for medicinal purposes rather than cosmetic ones. Two examples of these include anti-dandruff shampoos, which seek to stop itching and flaking symptoms and anti-alopecia shampoos, which attempt to reverse hair loss. These changes are so significant that products claiming to stop dandruff and reverse hair loss are classified as drugs and strictly regulated by the FDA.

In this chapter we review the various ingredients that have been used for anti-dandruff and anti-alopecia. We will discuss the development of these ingredients, their mechanisms of actions, and some of the challenges involved in formulating with them. We will focus on ingredients that have been proven effective, but will also mention those that are being experimented with now.

2. Dandruff and Anti-Dandruff Agents

Dandruff is a condition in which dead skin cells from the scalp come off in scales that are visible on the hair. The scales are dry, white or grayish and appear as small patches, especially at the top of the head. While it is normal for a small amount of skin cells to flake off due to normal skin growth, dandruff is a special case where an unusually large amount of flaking occurs. This is often accompanied by redness and irritation of the scalp. In some cases, dandruff may be a symptom of a more serious problem, such as seborrheic dermatitis, psoriasis or even head lice.

The cause of dandruff has only recently been determined.¹ DeAngelis, et al. showed that three factors were required for dandruff formation:

1. Natural sebaceous secretions—sebum which is made up of triglycerides and free fatty acids.
2. *Malassezia* fungi—normal resident flora on human skin and is related to yeast. It sustains itself by feeding on sebum.
3. Individual sensitivity—depends on how genetically susceptible they are to the condition.

The exact mechanism of dandruff formation is now believed to be the result of the formation of enzymes called lipases. The *malassezia* fungus uses these enzymes to break down sebum to oleic acid. The oleic acid then penetrates the top layer of skin and causes increased skin cell turnover in susceptible people. This in turn causes dandruff flakes and sometimes itching and redness.² Xu et al. have sequenced the *malassezia* fungi which aided in determining its mode of action.

Dandruff is a treatable condition that generally causes no health problems or permanent damage. The current strategy

for treating dandruff, namely using some compound to control the growth of malassezia, has been available for many years despite only recently learning the specific cause.

2.1. FDA Regulation

In the United States, anti-dandruff products are classified as drugs and are regulated by the Food and Drug Administration (FDA). The ingredients and claims that can be used for anti-dandruff products in the United States are in CFR Title 21, Volume 5, Part 358, Subpart H and were first issued in 1991. They currently include the ingredients listed in **Table 1**.

Only five ingredients were included in the original monograph including coal tar, salicylic acid, sulfur, selenium sulfide and zinc pyrithione. If manufacturers want to use different active ingredients for anti-dandruff products, they must file a new drug application (NDA) with the FDA. Ketoconazole went through the NDA process and is now approved for use as an anti-dandruff ingredient. Products containing effective levels of these ingredients can be sold without a prescription as long as they provide adequate detailed information and adherence to specific claims on their labels.

Table 1. Approved and unapproved anti-dandruff ingredients

Ingredient	Approved Concentration Range	Application
Coal tar	0.5 to 5%	Rinse off
Salicylic acid	1.8 to 3%	Rinse off
Selenium sulfide	1%	Rinse off
Sulfur	2 to 5%	Rinse off
Zinc pyrithione	0.3 to 2%	Rinse off
Zinc pyrithione	0.1 to 0.25%	Leave on
*Ketoconazole	1%	Rinse off
*Not in original monograph but recently approved for antidandruff shampoos		

Anti-Alopecia Materials/Anti-Dandruff Agents

Table 1. Approved anti-dandruff ingredients (Cont.)

Ingredients NOT demonstrated to be safe and effective
Alkyl isoquinolinium bromide
Allantoin
Benzalkonium chloride
Benzethonium chloride
Boric acid
Calcium undecylenate
Captan
Chloroxylonol
Colloidal oatmeal
Cresol, saponated
Ethohexadiol
Eucalyptol
Juniper tar
Lauryl isoquinolinium bromide
Menthol
Mercury oleate
Methylbenzethonium chloride
Methyl salicylate
Phenol
Phenolate sodium
Pine tar
Povidone-iodine
Resorcinol
Sodium borate
Sodium salicylate
Thymol
Undecylenic acid

2.2. Coal Tar

Coal tar is an ingredient produced as a byproduct during the conversion of bituminous coal to coke or coal gas. It is a thick brown or black liquid with a pungent odor. Coal tar is a complex mixture made up of various phenols, heterocyclic compounds, sulfur, nitrogen compounds and polycyclic aromatic hydrocarbons.³ It is believed that coal tar is made up of over 10,000 different compounds.

Coal tar was studied extensively in the early 1800's and was discovered to contain many useful chemicals.⁴ It found many applications including use as an antiseptic, dye, and eventually as a hair product. By the late 1800's, consumers were able to purchase anti-dandruff products containing coal tar. It has been used for this purpose ever since. Currently, products such as Denorex and Neutrogena T/Gel shampoos use coal tar as their active ingredient.

It has been shown that coal tar works by helping to slow the rapid growth of skin cells (one of the causes of dandruff). Having fewer skin cells helps to reduce inflammation, itching and scaling of both psoriasis and dandruff.

When formulating a coal tar anti-dandruff shampoo, the ingredient must be incorporated into formulas between 0.5 and 5.0 % according to FDA regulations.⁵ Coal tar can be difficult to stabilize and consumers are often encouraged to "shake well" before use of the product.

Coal tar is often the ingredient of last resort because it has some significant drawbacks:

- Coal tar has an odor that is not easily masked by fragrance.