

**TABLE 29.4**  
**Percutaneous Absorption of Hair Dyes and Correlation with Partition Coefficients**

Compound	pKa	Octanol/Water	Stratum	Permeability Constant (cm/hr <sup>1</sup> )
		Partition Coefficient	Corneum/Water Partition Coefficient	
p-Phenylenediamine	6.3	0.5	ND	$2.4 \times 10^{-4}$
o-Phenylenediamine	4.8	1.4	6.9	$4.5 \times 10^{-4}$
2-Nitro-p-phenylenediamine	3.9	3.4	13.0	$5.0 \times 10^{-4}$
2-Amino-4-nitrophenol	7.1	13.5	ND	$<3.0 \times 10^{-5}$ ( $6.6 \times 10^{-4}$ )
4-Chloro-m-phenylenediamine	4.1	7.0	ND	$2.1 \times 10^{-3}$
4-Amino-2-nitrophenol	7.8	9.1	13.0	$8.6 \times 10^{-5}$ ( $2.8 \times 10^{-3}$ )

<sup>1</sup> Values were obtained with a borate buffer (pH 9.7) as the vehicle. Numbers in parentheses were obtained in water to prevent ionization. Results are the mean of three to seven determinations.

ND = not determined.

Source: Reference 9.

skin membrane/water partition coefficients (Table 29.4). The permeability constants determined for these dyes were in the same rank order as the octanol/water partition coefficients, except for 4-chloro-m-phenylenediamine. Stratum corneum/water partition values correlated in a reverse order when compared with skin permeability constant values. It was apparent that once binding of the hair dye to the membrane was saturated, the partition coefficients more closely correlated with the rank order of the permeability constants. It was concluded that the prediction of percutaneous absorption of the homologous series of hair dyes was most closely associated with the oil/water partition coefficient, but this may be confounded by the capacity of the dye to bind to skin components.

## 29.5 EXAMPLES OF SPECIFIC HAIR DYE SKIN ABSORPTION STUDIES

### 29.5.1 LAWSONE

Lawsone (2-hydroxy-1,4-naphthoquinone) is the principal color ingredient in henna, a color additive approved with limitations for coloring hair by the FDA under 21 CFR 73.2190. In 2004, the Scientific Committee on Cosmetics and Non-Food Products (SCCNFP) (19) concluded that lawsone was mutagenic and not allowable as a hair coloring dye. Studies were done to determine the extent of lawsone absorption through human skin. Lawsone skin absorption was determined from two hair coloring products and two shampoo products, all containing henna (20). It was found that the majority of the lawsone remained in the skin, with only slight amounts found in the receptor fluid contents. Therefore, for exposure assessment purposes, receptor fluid values would be a good estimate of lawsone systemic absorption, and lawsone skin levels should not be included.

In 2013, the Scientific Committee on Consumer Safety (SCCS) released an opinion on an assessment based on henna batches numbers 1271 and 830.72 (21) that contained a maximum concentration of 1.4% lawsone. For example, when 100 g henna powder is mixed with 300 mL boiling water, put into a formulation, and applied as indicated under functions and uses, henna was considered safe for use by the SCCS under these consumer conditions of use. This assessment of henna powder safety does not pertain to other henna extracts, other compositions, or higher use concentrations. The SCCS also asked for a reassessment of the genotoxicity testing of lawsone.