paper to moist air so that its structure can gradually expand to the required level. Conservators use the colloquial term 'relaxed' to describe this state. Humidifying is carried out in a humidity chamber or in a Gore-Tex™ and damp blotter 'sandwich' (see Chapter 9). Alternatively, paper is misted with fine water droplets generated with either an ultrasonic humidifier or spraying device. Conditioning paper to moisture reduces surface tension and the risk of air bubbles being trapped at the object's surface, which will prevent uniform washing.

As washing is never complete without successful drying and since paper drying progresses at a much slower rate than wetting, an appropriate drying method has to be planned as part of the washing treatment (see Chapter 13). This also affects planning how to stop treatment should this be necessary.

11.4 Washing treatments

The following sections describe common washing methods for single-sheet paper objects. The methods are explained by their mechanisms in conjunction with practical application and evaluation. To explain transport mechanisms we refer to flow in and out of paper. With regard to structure we refer to *recto* (the image-carrying side), *verso* (the reverse side) and *paper matrix* (the core of the paper mat). When describing individual washing methods we focus on the migration and removal of yellow-brown discolouration. The movement of soluble products in paper is also illustrated using model samples with highly water-soluble red food dye (Hamilton, 2005) (**Fig. 11.6**). Food dye, being easily seen in white paper, helps one to visualize the possible migration directions of highly soluble matter that may behave similarly to discolouration or water-sensitive media. Depending on the method, flow of discoloured water will take different routes. These are illustrated diagrammatically with arrows marking the main directions of the outflow.

11.5 Immersion washing

Immersion washing involves submerging paper in a bath of water, usually inside a flat-bottomed tray or sink (**Fig. 11.7**). Water should have free access to the object from all sides. Paper will spontaneously imbibe water and, ideally, this should occur evenly across the sheet. Once hydrated and dissolved, discolouration and acidic substances will diffuse into the surrounding bath water driven by the concentration gradient (**Fig. 11.8**).

Conditioning the object to moisture prior to immersion is especially essential with immersion washing. Without it, the considerable surface tension generated between water and dry paper or media can lead to abrupt dimensional change resulting in paper distortion and dislocation of loosely attached media particles. Surface tension will also slow down wetting of a dry sheet.

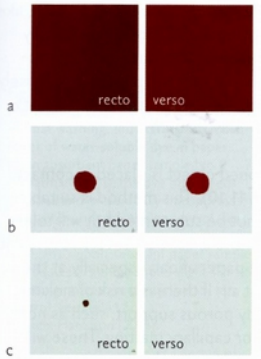

Fig. 11.6 Model samples (controls) used in the following to illustrate the movement of water-soluble dye during different washing methods. (a) Sample No. 1 (Whatman No. 1) recto and verso of absorbent paper, with highly water-soluble red food dye applied overall. (b) Sample No. 2 (Whatman No. 1) with the dye applied locally. (c) Sample No. 3 (sized Arches) recto and verso of absorption-resistant paper, with the same dye applied locally.
Source: Hamilton (2005).

Absorbent paper will imbibe water rapidly and settle at the bottom of the tray, posing a risk of discolouration accumulating beneath the paper, which will slow down the washing action on the verso. This will necessitate lifting the object in order to agitate the water. Absorption-resistant paper (e.g. hard-sized paper) may float or partially float, which can lead to the formation of tidelines along the wet and dry boundary where exposed to the air (Eusman 1995, Dupont 1996a, b). In this case, the sheet should be gently forced under the surface of the water. Given sufficient time, absorption-resistant paper will likewise absorb water through diffusion, eventually becoming saturated.

As yellow-brown solution leaches out of paper, it concentrates near the surface of the object and takes a while to mix with bath water. Water has to be agitated or changed and the item lifted to increase the concentration gradient and encourage diffusion. When changing bath water the paper on its support may be placed on a blotter. Contact with blotter results in the fast removal of bulk water from paper due to capillary pressure and gravity, which supports the cleaning action.

Evaluation: Assuming that paper wets evenly and that sufficient time is allowed for the process, immersion washing can be an efficient and economic method for uniform removal of discolouration (**Fig. 11.9**). It needs simple equipment and requires little manipulation unless the object shows a tendency to float or settle at the bottom of the tray. The disadvantage of immersion washing is that, once the item is im-

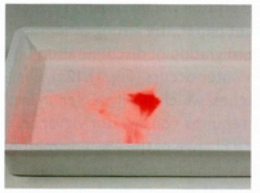

Fig. 11.7 Model sample No. 2 during immersion washing. Water-soluble dye bleeds in a random manner out of the paper.

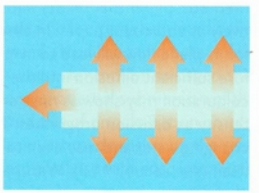

Fig. 11.8 Main flow direction of discolouration during immersion washing.

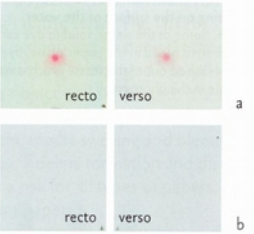

Fig. 11.9 Model sample No. 3 photographed in the course of immersion washing. (a) Water-soluble dye diffused in the paper on recto and verso. (b) After sufficient immersion time to demonstrate complete removal of the dye from the paper. For control, see Fig. 11.6c.
Source: Hamilton (2005).