Philosophical Magazine Series 4

ISSN: 1941-5982 (Print) 1941-5990 (Online) Journal homepage: http://www.tandfonline.com/loi/tphm15

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To cite this article: Charles Tomlinson (1863) XXVI. On the action of oils in arresting the motions of camphor on water , Philosophical Magazine Series 4, 26:174, 187-190

To link to this article: http://dx.doi.org/10.1080/14786446308643540

Published online: 26 May 2009.

of moderate violence occurred during the hail-storm, each of which was attended by a redoubled fall of hailstones" (ibid. vol. iv.). Tessier, in his 'Notes on the Locality in France ravaged by the Hail-storm of 1788,' remarks, "the hail followed immediately after the lightning and thunder" (*Mémoires de l'Académie*, 1789). We might cite many other facts in illustration; some others are quoted in the memoir from which this extract is derived, but those already referred to suffice to show that hail is in all probability formed at the moment of the electric discharge from the storm-cloud.

This theory does not require the supposition of the presence of two clouds, which frequently does not happen. It is not necessary to suppose the existence of two contrary winds, which often is not met with. Again, it is not necessary to suppose the storm-clouds to be at a very great elevation. On the contrary, this hypothesis furnishes an explanation why hail falls in these climates during the summer and at the hottest portions of the day; it is because at such periods, when the air is most dry, the electric tension becomes more considerable than in strata of air of a higher elevation, and at hours of the day when the temperature is less.

In fine, the former of the two portions of this theory is not hypothetical but a demonstrable fact; whilst, as to its latter portion, it may be remarked that if it be indisputable that hailstones are almost instantaneous in their formation, their cause also must be equally instantaneous, and there is no other cause than the one suggested which can operate in such a manner.

XXVI. *On the Action of Oils in arresting the Motions of Camphor on Water.* By CHARLES TOMLINSON, *Lecturer on Physical Science, King's College School, London*.*

AMONG the numerous physicists who have studied the motions of camphor on water, from the time of Volta in 1787 to that of Dutrochet in 1842, no one doubted or qualified the statement that if the surface of the water be touched with oil the motions are instantly arrested. Thus Volta says, "If the water be defiled with any foreign substance, or its surface only slightly fouled with oily matter, if only the dust of the room be upon it, the looked-for motions of camphor and of benzoin will not take place, or will be so feeble as to be scarcely sensible."

In a paper read before the Royal Society about eighteen months ago†, one of my conclusions was, that an essential oil may arrest

* Communicated by the Author.

† See Philosophical Magazine, vol. xxiv. p. 490.

the camphor-motions only during its solution and evaporation, and that when got rid of by those processes the motions will set in as before. This remark was not meant to apply to all the essential oils; and some results that I have lately obtained define the conditions of the limitation.

A flat glass dish, 6 inches in diameter, made chemically clean, was nearly filled with clean water, and some fragments of camphor from a freshly-cut surface were scraped upon the water with the point of a penknife-blade. The fragments rotated with great vigour. A drop of "rectified spirits of turpentine" was gently delivered to the surface of the water from the end of a glass rod; the turpentine flashed out into a film, and the camphor fragments were struck motionless—*comme foudroyées,* as Prevost has it, or "as if by magic," according to Venturi's remark. Fresh fragments of camphor were thrown on the surface at intervals during thirty hours, but no motion was produced.

Camphor was set spinning in a similar clean vessel, and a drop of oil of rosemary was placed on the surface; the film instantly arrested the motions, but in about forty minutes fresh fragments rotated briskly.

The experiment was repeated several times with different oils, &c., with similar results: the oils were cajeput, patchouli, carraway, cubebs, eucalyptus, and some others, as also creosote and carbolic acid. This additional fact was noticed with respect to the oily films of carraway and cubebs—that fresh camphor fragments rotated briskly in them. It was also found that a drop of the oil of bitter almonds or of aniseed does not arrest the motions of the camphor fragments at all.

I may here remark that oil of aniseed is well adapted to explain what seems to me to be the true cause of the camphor-motions, namely that a film is detached from the camphor itself by the adhesion of the water, which film, reacting on the fragment, produces motion after the manner of the electrical star, Barker's mill, &c. The oil of aniseed becomes solid so readily at a moderate degree of cold, that fragments of it may be used to show rotations on water after the manner of camphor. In the case of camphor, the motions are very rapid, and the film that produces them is, under ordinary circumstances, invisible; whereas in the case of solid aniseed these rotations are slow and the film visible, so that the action can be studied under the great advantage of having all the conditions at command. The film from the fragment of aniseed is pushed forward in one direction, while the fragment itself moves in the opposite direction; and this continues until the adhesion of the surface is satisfied, and then the motions are brought to an end. If the film, as fast as it is formed, is got rid of by solution and evaporation, as in the case of camphor, the motions go on until the whole of the solid is disposed of. If the surface be touched with an oil or any substance that spreads out into a film so as to prevent the camphor film from forming, the rotations cease. A little flour from the point of a penknife will spread out over the surface and stop the motions. Oils do this very effectually; and it was supposed, up to the date of my essay, that any kind of oil would permanently arrest the camphor-motions. My experiments led me to the conclusion that volatile oils that leave no residue, arrested the motions only during their solution and evaporation. I now go much further, and show that certain oils do not arrest the camphor-motions at all, and that in such cases the camphor film has a stronger adhesion to the surface of the water than that of the oils in question.

The reason why the fixed oils stop these motions is, that they form permanent films, displacing the camphor film, and preventing its adhesion to the water. Volatile oils such as turpentine, contain products of oxidation which are neither soluble nor volatile; and these arrange themselves in the form of a delicate permanent network over the surface of the water, and effectually prevent the adhesion of the camphor fragments. Such products of oxidation can, however, be got rid of by distillation. For this purpose about an ounce of turpentine was distilled from off caustic potash; and when a drop of the distillate was placed on the water among the rotating fragments, the resulting film displaced them for a moment, but did not stop the rotation. On the contrary, they immediately invaded the oily-looking film, skating in and through and about it, and leaving long trails free from oil behind.

This, then, is a case in which the camphor film has a stronger adhesion for the water than the camphene film has. A large number of oils, isomeric with oil of turpentine, and reputed commercially pure, were tried, but they all more or less stopped the rotation of the fragments. On rectifying them by distillation, they either did not arrest the motions at all, or those motions set in again as soon as the film had evaporated.

Oil of bitter almonds is not liable to be acted upon by the air in the same manner as the turpentine oils; it partly evaporates and partly forms benzoic acid, which is one of the gyrating substances. It is, moreover, displaced by the camphor film; hence it does not arrest the camphor-motions. The same remark applies to Persian naphtha, belmontine, Young's paraffine oil, some specimens of rock-oil (rectified) from Canada and Newfoundland. One specimen, of a deep yellow colour, arrested rotation; it was distilled, and the distillate had no retarding effect.

In order to stop the camphor-motions, the oily film, whether visible or not, must cover the whole surface of the water. If the point of a pin be dipped into turpentine and then into the water in the 6-inch vessel, the fragments will be repelled, but will not cease to rotate except in and about the small film produced by the pin. The head of a pin dipped in turpentine produced a film large enough to cover the whole surface and arrest the motions.

It was suggested to me by Professor Miller to add a minute quantity of resin to the film of camphene while the camphor fragments were moving about in it. A little powdered resin dusted on the surface had no other effect than that of mechanically clogging the motions without arresting them; but the head of a pin dipped into an alcoholic solution of resin and then into the camphene film on the water, had the effect of stopping the motions of the camphor fragments.

King's College, London,
August 10, 1863.

XXVII. *On the Position of the Oscillations of the Æther-particles in a Rectilinearly Polarized Ray of Light. By* Dr. G. Quincke*.

THE question whether the vibrations of the æther-particles are perpendicular to the plane of polarization, as Fresnel assumed †, or, as Prof. Neumann maintains ‡, take place in the plane of polarization itself, is closely connected with the question whether the density or elasticity of the æther is different in different media. Neumann arrived at the latter view, that the vibrations take place in the plane itself, by developing the theory of double refraction from the same principles as those which Fresnel had already established. Considering further that Fresnel, in developing the laws of reflexion for transparent substances, assumes that the density of the æther is variable, but afterwards, in the theory of double refraction, assumes that the elasticity is variable, it is even doubtful for which assumption he would ultimately have decided §.

Opinions are divided which is the just assumption; and while most of the French philosophers, along with MM. Ångström ||,

* Communicated to the Berlin Academy of Sciences by Prof. Magnus.

† *Mém. de l'Acad. Roy. d. Scienc.* vol. vii. Pogg. *Ann.* vol. xxiii. 1831, p. 539.

‡ Pogg. *Ann.* vol. xxv. 1832, p. 451, and *Abhandl. d. Berl. Akad.* 1835, p. 5.

§ Compare also Fresnel, lettre à M. Arago, *Ann. de Chim.* vol. ix. 1818, p. 287.

|| Pogg. *Ann.* vol. xc.