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The reality of Tawfik constants

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Abstract

Three constants were published by Tawfik et al. for the thermoelectric, pyroelectric and dielectric properties of ferrites. Fair discussion and analysis was carried out in the viewpoint of the well established scientific facts and bases, experience and literatures. The conclusion is that these constants are false and have no real existence.

Keywords: Dielectric; Ferrite; Thermoelectric

Recently Tawfik et al. [1–5] announced the discovery of Tawfik constants and coefficients during their dielectric [1], thermoelectric [2] and pyroelectric [3–5] studies of Cu-substituted NiZn ferrites. The aim of this comment is to discuss the reality and validity of the so called Tawfik constants and coefficients.

When Tawfik et al. [1] studied the temperature-dependence of the dielectric constant (K–T as in Fig. 1 which was repeated in Fig. 5 as $K - 1/[T_c - T]$ of Ref. [1]). They mentioned that "From the slope of the line near the transition temperature T_c of Fig. 5 Tawfik constant A can be determined [1]". The results of Fig. 5 can be expressed in the form:

$$K = A/(T_c - T) + B \tag{1}$$

where B is constant and A is the Tawfik constant. The Curie–Wiess law [6, 7], which is valid for ferroelectric materials, takes the form:

$$K = C/(T - T_c) + K_\infty \tag{2}$$

where C is the Curie constant, which is the reciprocal of the thermal expansion coefficient of the crystal, and K_∞ is the permitivity at infinitely high frequency. It is clear that Eq. (1) which was drawn by Tawfik in Fig. 5 [1] for ferrimagnetic CuNiZn ferrites

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is typically the same as Eq. (2) or the Curie–Wiess law [6, 7] which holds only for ferroelectric materials. Moreover the so-called Tawfik constant A is exactly the Curie constant C. Tawfik et al. [1] did not support their discovery from the literature, neither theoretically nor experimentally. Moreover, they ascribed to ferrimagnetic materials the properties of ferroelectrics. Indeed the temperature-dependence of the dielectric constant for ferrimagnetic materials was treated theoretically and verified experimentally [8, 9] on the basis of Koop's theory for dielectric structure [8] and not on Curie–Wiess law.

Studying the temperature-dependence of the thermoelectric voltage ($TEMF$–$[T - T_c]$ as shown in Fig. 4) for CuNiZn ferrites, Tawfik et al. [2] discovered another new constant, it is the Tawfik coefficient α which was defined as the thermoelectric power (properly this is the thermoelectric voltage) per unit area A. They specify the Tawfik coefficient as follows:

$$TEMF = \alpha A(T_c - T) \tag{3}$$

According to Fig. 4 [2] a constant B must be added to Eq. (3):

$$TEMF = \alpha A(T_c - T) + \text{constant} \tag{4}$$

The thermoelectric power has to be replaced by thermoelectric voltage over the whole manuscript of [2] according to the units used by the authors. The thermoelectric power can be written in the form [10]:

$$TEP = \pm(\gamma/e)[1/T] + \text{constant} \tag{5}$$

where γ is a constant of energy units. When the majority of the charge carriers are electrons the negative sign is used while the positive sign is for holes. Comparing Eq. (4) with Eq. (5) taking into consideration that TEP = TEMF divided by temperature difference (i.e. $TEP = \Delta V/\Delta T$, ΔT has to be constant for all samples during measurements) it could be observed that Tawfik omitted the constant term, on the other hand Eq. (4) by Tawfik is wrong because it indicates that thermoelectric voltage is directly proportional to the temperature while the well known fact [8] is that thermoelectric power (voltage) is inversely proportional to temperature, as in Eq. (5).

Pyroelectric properties for CuNiZn ferrites were studied by Tawfik et al. [3–5]. These papers are essentially similar but Tawfik omitted the names of the other authors and republished paper [5] as a single author. Tawfik defined the pyroelectric field E as the pyroelectric voltage V divided by the thickness d of the sample ($E = V/d$). The results of Fig. 5 i.e. (E against T) are represented again in Fig. 6 [3–5] as a function of $1/(T_c - T)$. A third new constant A, the Tawfik constant, was deduced from Fig. 6 [3–5]. Results in Fig. 6 [3–5] can be expressed as:

$$E = A/(T_c - T) + \text{constant} \tag{6}$$

The values of the pyroelectric field E in Figs. 2, 5 and 6 [3–5] ranged up to 1800 V cm^{-1}, taking into consideration the thickness of the samples in mm, these high values of pyroelectric field or voltage seem to be impossible. It was reported [11] that many pyroelectrics are at the same time piezoelectrics or ferroelectrics or both. Triglycine sulfate, triglycine fluoroberyllate, triglycine selenate, barium titanate, Rochelle salt, lithium niobate $LiNbO_3$, the compound $LiSO_4 \cdot 10H_2O$, $LiTaO_3$, yellow potassium prussiate $K_4Fe(CN)_6 \cdot 3H_2O$, and resorcinol are examples of pyroelectrics [11]. In the literature and text books nothing can be found about the pyroelectric properties of ferrimagnetic materials except in those papers by Tawfik et al. [3–5]. The values of T_c can be determined by DTA (differential thermal analysis) or at the transition point in the relationship $\ln \rho - 1/T$ (ρ is the electrical resistivity). But $\ln \rho - 1/T$ in Fig. 1 [12] represents straight lines without any transition points which means that Tawfik et al. [12] failed to determine T_c for these studied samples. They mentioned that they used T_c values from DTA presented in Fig. 3 [13, 14], but observers of this figure will not find any exothermic peaks at T_c as Tawfik et al. [13, 14] suggested. The small peaks found in the range 20–100°C which appear during heating and completely disappear during the cooling cycle to room temperature, are related mainly to humidity present on and under the surfaces of the samples. It is obvious that Tawfik et al. [3–5] used doubtful values of T_c in the graphical representation of results and on the other hand supposed that ferrites have pyroelectric and ferroelectric effects; this is impossible and never before observed.

Finally it is necessary to conclude the following:

(1) Tawfik et al. [1], contrary to all accepted beliefs, considered that ferrimagnetic materials follow the same dielectric character of ferroelectric materials by using Curie–Wiess law, therefore Tawfik constant A for the temperature-dependence of the dielectric constant is wrong.

(2) Tawfik et al. [3–5] proposed the discovery of pyroelectric properties of ferrites, which is impossible; Tawfik constant A for the temperature-dependence of the pyroelectric field is, therefore not true.

(3) Tawfik coefficient α [2] for the temperature-dependence of thermoelectric power is wrong because the thermoelectric power (or voltage) is inversely proportional to the temperature and not directly as stated by Tawfik [2].

(4) Tawfik et al. represented K, $TEMF$ and E as functions of $(T - T_c)$, the values of T_c used are suspect, consequently the constants will be doubtful also.

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