Corrosion failure of metals can be considered a combination of metal oxidation and reduction of cathode depolarizers in the medium. Water molecules and \( \text{H}_3\text{O}^+ \) ions are referred to as such depolarizers. Their reduction is accompanied by hydrogen release. The corrosion rate mainly depends on the intensity of the hydrogen release, which is determined by an electrochemical overvoltage of the process. Therefore, an investigation into the correlation between the overvoltage of the hydrogen release and physical and chemical properties of a corroding metal is of interest.

The rate of cathode release of hydrogen both from acid and alkali solutions substantially depends on an electrode material. The dependence of the overvoltage of the hydrogen release \( \eta \) on the density of the polarization current \( i \) is described by the Tafel equation \( \eta = a + b \log i \). In this equation, the \( a \) constant is increased from 0.1 to 1.56 when passing from a platinum electrode to a lead one [1]. To explain the impact of the nature of metal on the hydrogen overvoltage, various physical and chemical properties of metals such as the work function of an electron, minimal interatomic distance in a crystal lattice, the factor of compacting under pressure, temperature and heat of phase transformations, catalytic activity with respect to recombination of separated hydrogen atoms, etc., were involved [1]. As there are many parameters, the most important ones should be first determined, and the possible contribution of each of them should be estimated. A fundamental parameter determining all principal properties of metal is its electronic structure. It should be considered a primary one. As hydrogen is liberated at the metal–electrolyte interface, the properties of the metal surface will be of the first priority. In regard to the hydrogen release overvoltage, volume properties are useful to the extent to which they are connected with the surface properties.

One of the most important parameters of the surface that determine the intensity of the intermolecular forces and polarity of a substance is the specific free surface energy (SFSE) [2]. Its value at 298.2 K is chosen as a parameter that influences the hydrogen-release overvoltage [3]. The value of the constant \( a \) in the Tafel equation that corresponds to the overvoltage of electrode process at the current density of 1 A/cm\(^2\) was used as a quantitative parameter of the overvoltage [1]. The constant \( b \) does not substantially depend on the nature of metal. It appeared that rather good correlation between selected parameters takes place (see Fig. 1).

As mentioned above, SFSE characterizes the intensity of the field of molecular forces and polarity of the substance. A similar parameter that also reflects the contribution of orientation forces into intermolecular interaction is \( \psi \)-factor, which includes deviation from a straight line of the dependence of boiling temperature \( V \) and molar volume of a liquid at this temperature observed for polar (nonspherical) molecules [4]: \( \psi = 0.1 \log T - 0.122 \log V + 0.006 \).
Fig. 1. Dependence of the Tafel constant of the process of hydrogen release on the specific free surface energy of metals.

Fig. 2. Dependence of the constant $a$ in the Tafel equation of hydrogen release on the value of the $\psi$-factor of metals.

A quantitative relationship was revealed between the Lennard–Jones potential and the $\psi$-factor. This fact made it possible to assume that an application of $\psi$-factor will enable one both to estimate the interaction within the body of metal and predict the adsorption behavior of substances and, especially their hydrophilic properties. The