INTISARI

PENGEMBANGAN SENSOR RASA ASTRINGENSI DAN UMAMI BERBASIS KONTAK PADAT

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Sampai saat ini, sensor rasa berbasis membran lipid/polimer (LPM) masih mengadopsi desain elektroda kontak cair. Padahal, peneliti-peneliti telah lama mengusulkan berpindah ke desain kontak padat, yang dapat menyelesaikan batasan-batasan yang ditemui pada elektroda kontak cair. Oleh sebab itu, penelitian pada disertasi ini berusaha mengembangkan sensor rasa, khususnya rasa astringensi dan rasa umami, menggunakan desain kontak padat.

Sensor astringensi berbasis kontak padat dibuat dengan melapisi komposit *polypyrrole* dan *carbon black* (PPy-CB) ke atas elektroda *glassy carbon* (GC). Lalu, LPM dilapisi di atas permukaan GC/PPy-CB dengan metode penetesan. Hasil karakterisasi elektrokimia menunjukkan bahwa PPy-CB mampu meningkatkan stabilitas respon sensor, ditandai dengan diperolehnya kapasitansi sebesar 3,3 mF/cm^2. Perlakuan *annealing* pada PPy-CB dan *vapor-induced phase separation* pada saat deposisi membran dapat lebih meningkatkan kapasitansi menjadi 9,1 mF/cm^2. Investigasi respon profil sensor astringensi menunjukkan bahwa sensor astringensi memiliki sensitivitas terhadap asam tannin sebesar -17,997 mV/dekade. Selain itu, selektivitas sensor sangat baik yang ditandai dengan kecilnya respon terhadap sampel-sampel lima rasa dasar. Mekanisme *sensing* dijelaskan dari interaksi lipid *tetradodecylammonium bromide* (TDDAB) bermuatan positif terhadap grup fenolik-hidroksil yang bermuatan negatif pada asam tannin.

Sensor umami berbasis kontak padat dibuat dengan melapisi elektroda *screen-printed* (SPE) dengan polimer *poly*(3,4-*ethylenedioxythiophene*) termodifikasi *sodium dodecyl sulfate* (PEDOT:SDS) secara galvanostatik. Lalu, LPM dilapisi di atas permukaan SPE/PEDOT:SDS dengan metode penetesan. Karakterisasi impedansi menunjukkan bahwa lipid *methyltrioctylammonium chloride* (TOMACl) berperan sebagai penyedia utama konduktivitas ion di dalam membran, sedangkan lipid *bis(2-ethylhexyl) phosphate* (BEHP) berperan penting dalam mendeteksi sampel-sampel umami. Karakterisasi kronopotensiometri menunjukkan bahwa sensor memiliki kapasitansi sebesar 6,42 mF/cm^2. Uji respon sensor terhadap berbagai konsentrasi sampel dasar umami menunjukkan tren linier pada rentang 0,1-30 mM untuk potensial relatif, dan 1-300 mM untuk potensial residu. Uji stabilitas mingguan menunjukkan bahwa sensor umami dapat mempertahankan 92% – 96% respon awal setelah berumur 5 minggu. Mekanisme *sensing* sensor umami dapat dijelaskan dari kecenderungan senyawa umami yang mengekstrak H^+ dari lipid BEHP, sehingga menyebabkan potensial membran menurun. TOMACl berperan dalam melemahkan pengaruh kation.

Kata kunci: sensor rasa, astringensi, umami, elektroda kontak padat, karakterisasi elektrokimia

ABSTRACT

DEVELOPMENT OF ALL-SOLID-STATE ASTRINGENT AND UMAMI TASTE SENSOR

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Until now, lipid/polymer membrane-based sensors (LPM) still adopt a liquid contact electrode design. However, for membrane-based sensors, it is suggested to shift to a solid-contact design, which can overcome the limitations encountered in liquid-contact electrode. Therefore, the aim of this dissertation is to develop taste sensors, especially for astringency and umami tastes, using a solid-contact design.

All-solid-state astringent taste sensor was fabricated by coating a composite of polypyrrole and carbon black (PPy-CB) onto a glassy carbon (GC) electrode. Then, LPM is coated onto the surface of GC/PPy-CB using a drop-casting method. Characterization by impedance spectroscopy and chronopotentiometry show that the presence of PPy-CB as the intermediate layer enhances the stability of the sensor response, as indicated by the measured capacitance of 3.3 mF/cm^2. Annealing treatment on PPy-CB and vapor-induced phase separation (VIPS) during membrane deposition can increase the capacitance to 9.1 mF/cm^2. Investigations on the response profile of astringent taste sensor indicates that the sensor exhibits sensitivity to tannic acid of approximately -17.997 mV/decade. Additionally, the sensor demonstrates excellent selectivity against five basic tastes. The sensing mechanism is elucidated by the interaction between positively charged tetradodecylammonium bromide (TDDAB) lipid and the negatively charged hydroxyl-phenolic groups in tannic acid.

All-solid-state umami taste sensor was fabricated by electrodepositing poly(3,4-ethylenedioxythiophene) doped with sodium dodecyl sulfate (PEDOT:SDS) on a screen-printed electrode (SPE) using galvanostatic method. Subsequently, LPM is coated onto the surface of the SPE/PEDOT:SDS using drop-casting method. Impedance spectroscopy data revealed that methyltrioctylammonium chloride (TOMACl) provides ionic conductivity within the membrane phase, while bis(2-ethylhexyl) phosphate (BEHP) plays a crucial role in detecting umami samples. Chronopotentiometry characterization demonstrates that the sensor has a capacitance of approximately 6.42 mF/cm^2. Evaluation on sensor's respoonse toward various concentrations of umami basic samples yield linear trend of 0.1-30 mM for relative potential, and 1-300 mM for residual potential. Weekly stability tests indicate that umami sensors can maintain 92% – 96% of their initial response after 5 weeks. The sensing mechanism of umami sensors can be explained by the tendency of umami compounds to dissociate H$^+$ from BEHP, causing a decrease in membrane potential. TOMACl plays a role in weakening the influence of cations.

Keyword: taste sensor, astringency, umami, solid-contact electrode, electrochemical characterizations